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Muraoka

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(54) **FLUID FILLED TYPE VIBRATION DAMPING DEVICE**

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Dec. 27, 2007 (JP) 2007-337015

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F16F 5/00 (2006.01)

(52) **U.S. Cl.** **267/140.14**

(58) **Field of Classification Search** 267/140.13–140.15, 219, 141, 267/141.1–141.4; 248/562, 636, 638
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,913,392 A 6/1999 Eckel et al.
5,992,833 A 11/1999 Tanahashi
6,315,277 B1 * 11/2001 Nagasawa 267/140.14
6,422,546 B1 7/2002 Nemoto et al.
7,165,761 B2 1/2007 Muraoka et al.
7,188,830 B2 3/2007 Kato et al.
7,255,335 B2 8/2007 Muraoka et al.
7,322,570 B2 1/2008 Maeno et al.
2005/0006830 A1 * 1/2005 Nemoto 267/140.14
2006/0097437 A1 * 5/2006 Watanabe 267/140.14

FOREIGN PATENT DOCUMENTS

JP U-58-1843 6/1981
JP A-01-093638 4/1989
JP A-06-330980 11/1994
JP A-07-071506 3/1995
JP A-09-229136 9/1997
JP A-11-101294 4/1999
JP A-2000-213586 8/2000
JP A-2003-339145 11/2003
JP A-2005-133862 5/2005
JP A-2005-291276 10/2005
JP A-2006-097823 4/2006
JP A-2006-180601 7/2006

OTHER PUBLICATIONS

Oct. 11, 2011 Office Action issued in Japanese Patent Application No. 2007-337015 (with partial English Translation).

* cited by examiner

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(57) **ABSTRACT**

A vibration damping device including: a rubber elastic body connecting first and second mounting members; a partition member supported on the second mounting member; a pressure-receiving chamber and an equilibrium chamber connected by a first orifice passage; an oscillating plate defining the pressure-receiving chamber; and an electromagnetic actuator for actuating the oscillating plate. The oscillating plate is constituted by a cylinder shaped hole and a piston shaped plate accommodated within the cylinder shaped hole with a gap provided therebetween. An output member of the electromagnetic actuator is linked to the piston shaped plate. A plate spring extending in an axis-perpendicular direction is disposed to an opposite side from the electromagnetic actuator with the piston shaped plate therebetween, with the oscillating plate linked to and supported in an axial direction with respect to the partition member by the plate spring.

9 Claims, 6 Drawing Sheets

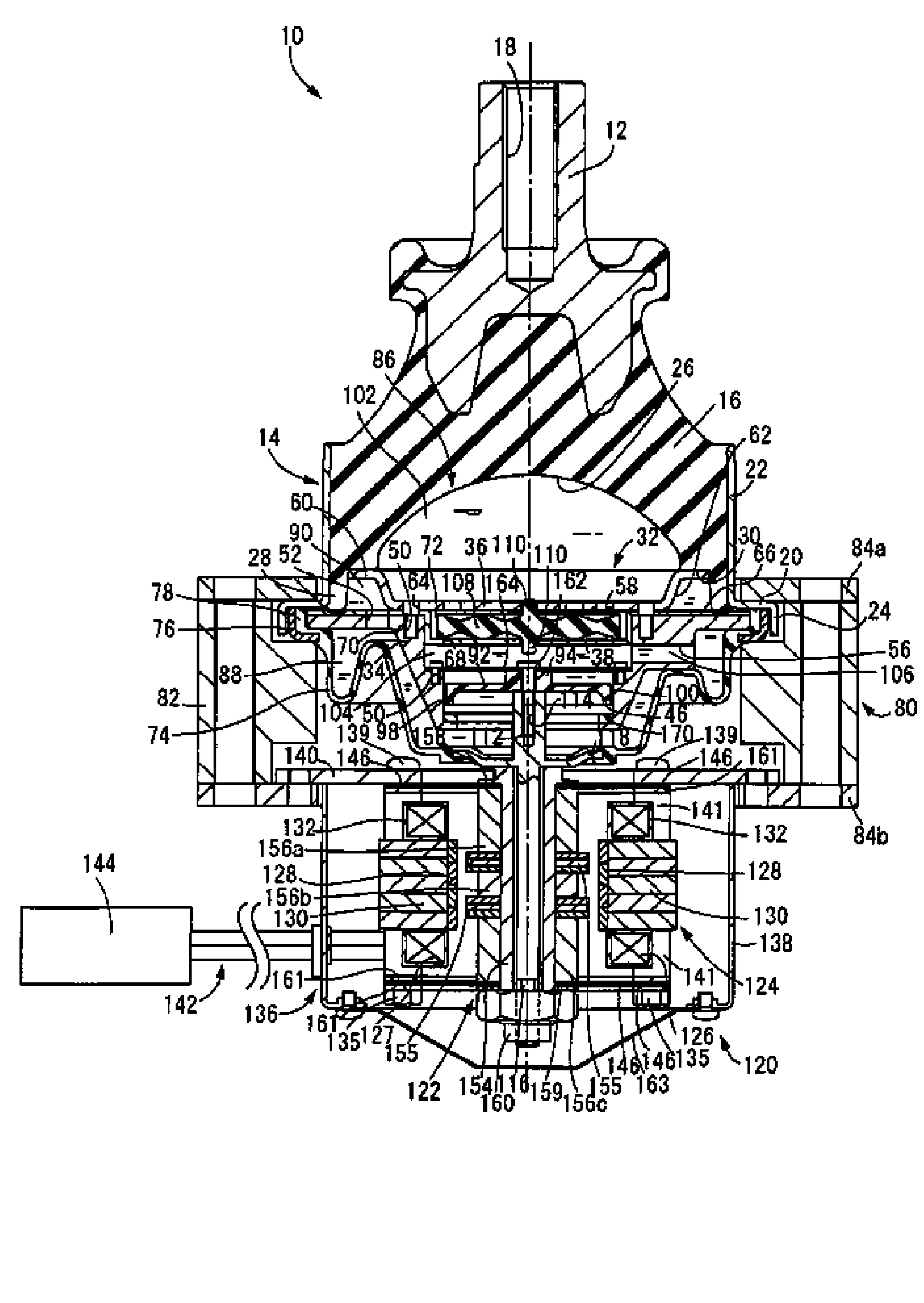

FIG.1

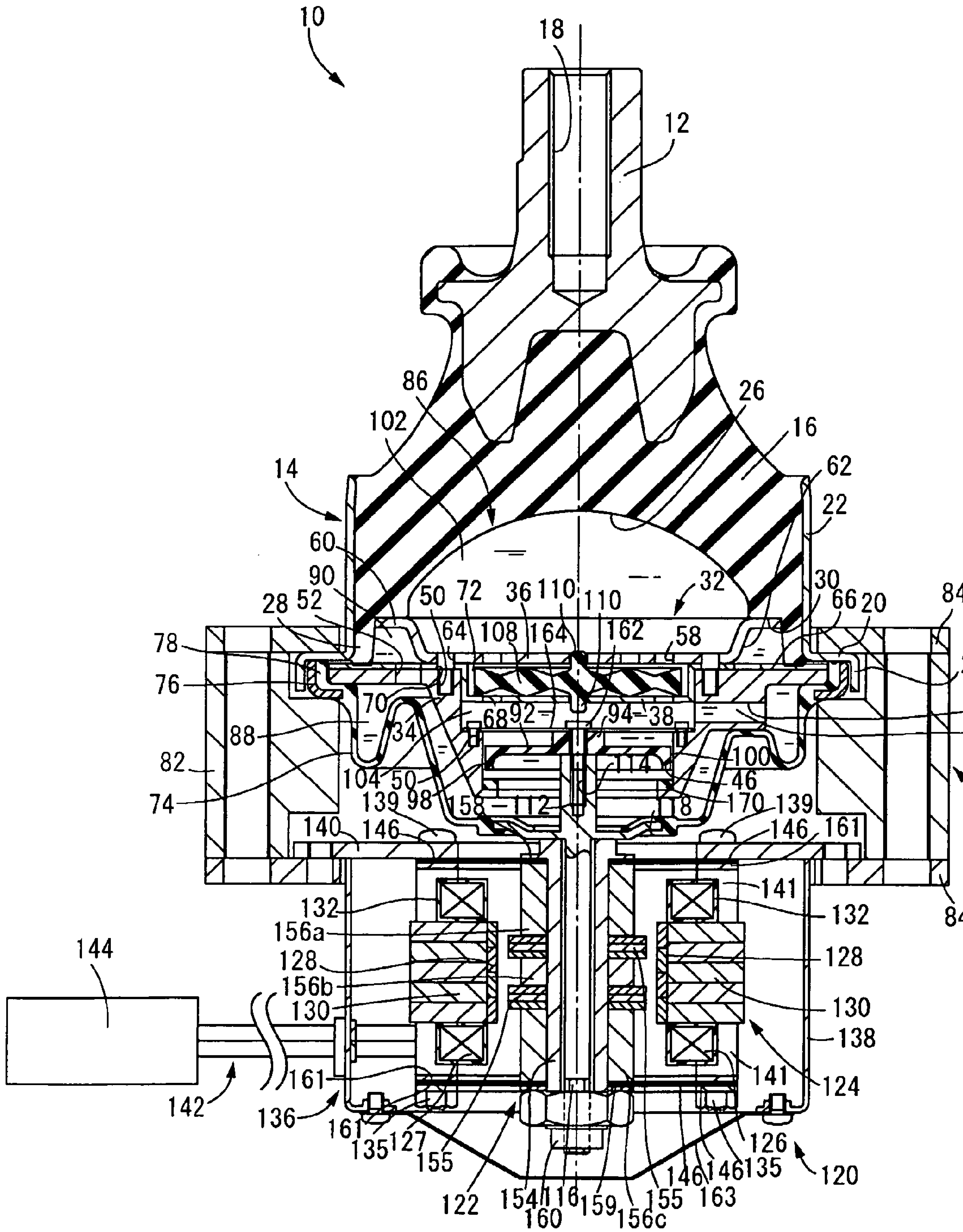
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FIG.2

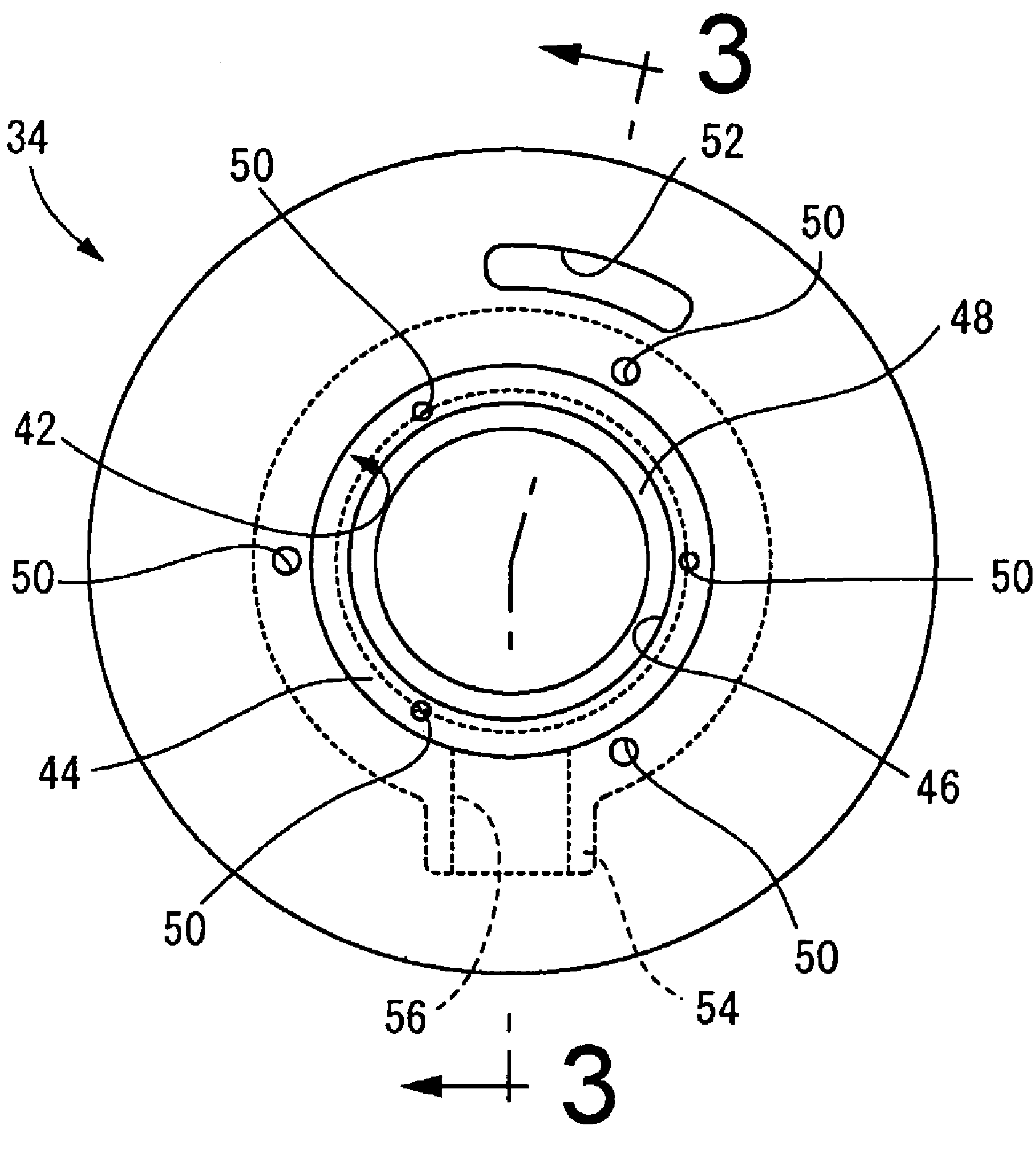


FIG.3

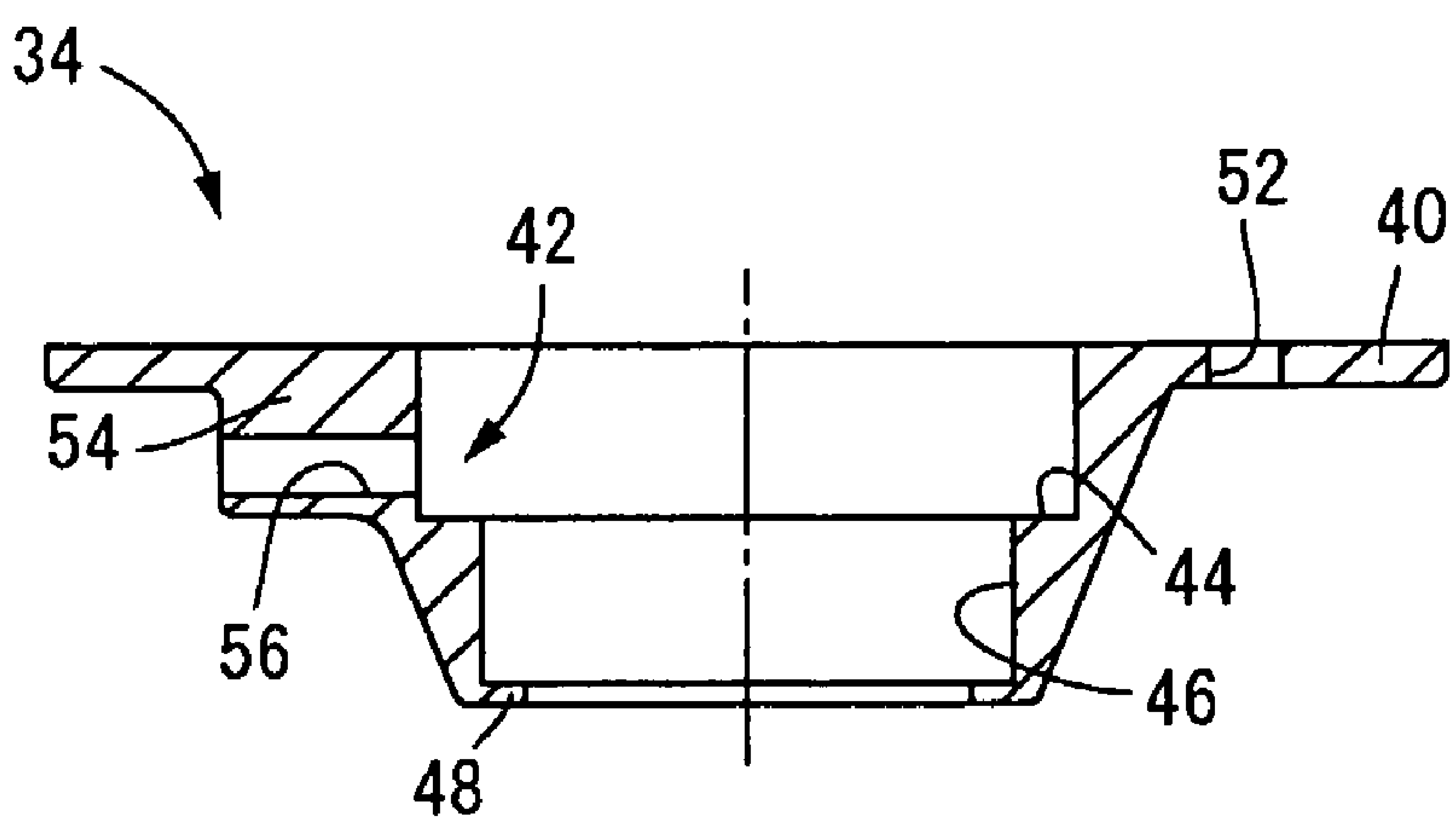


FIG.4

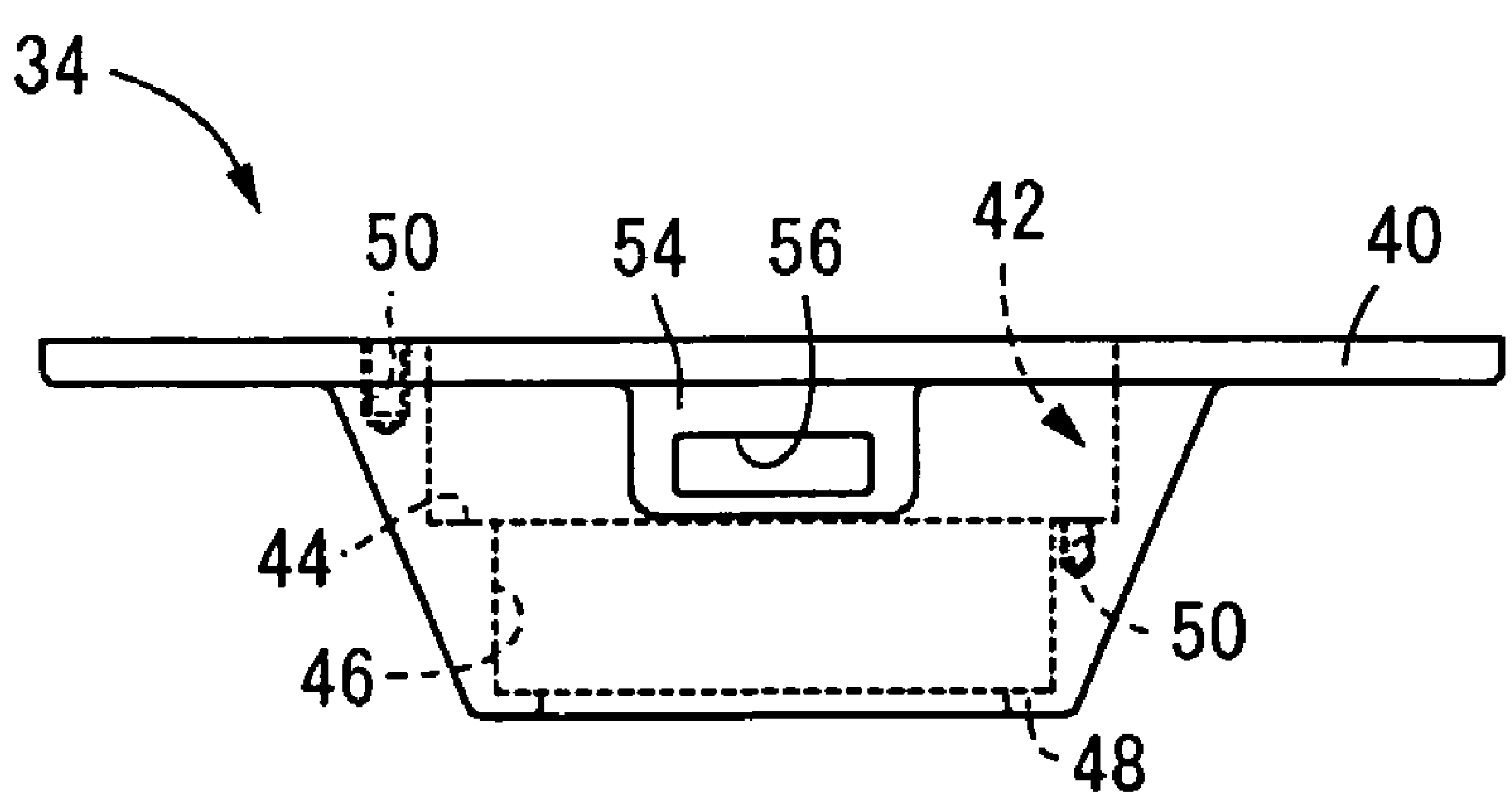
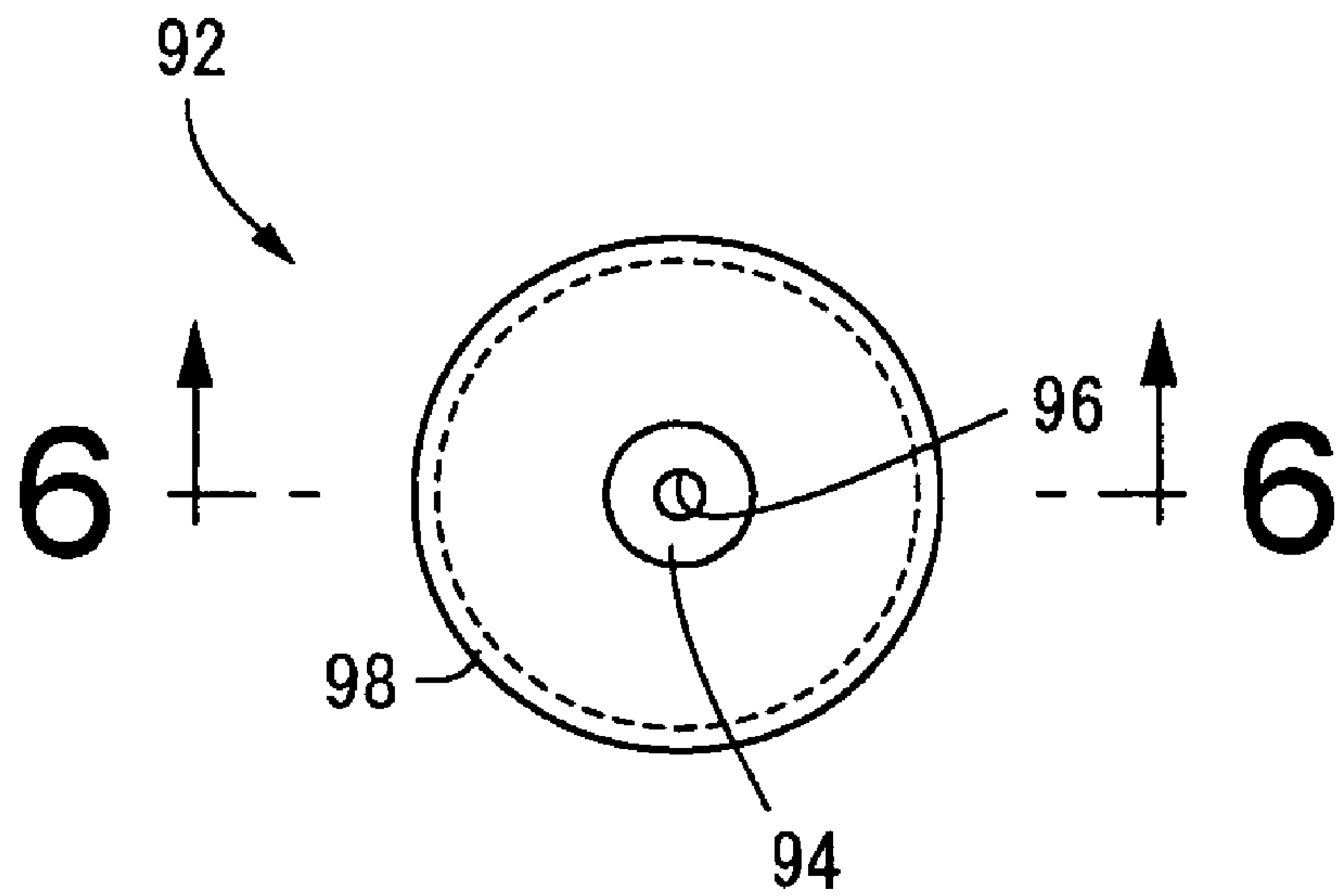


FIG.5



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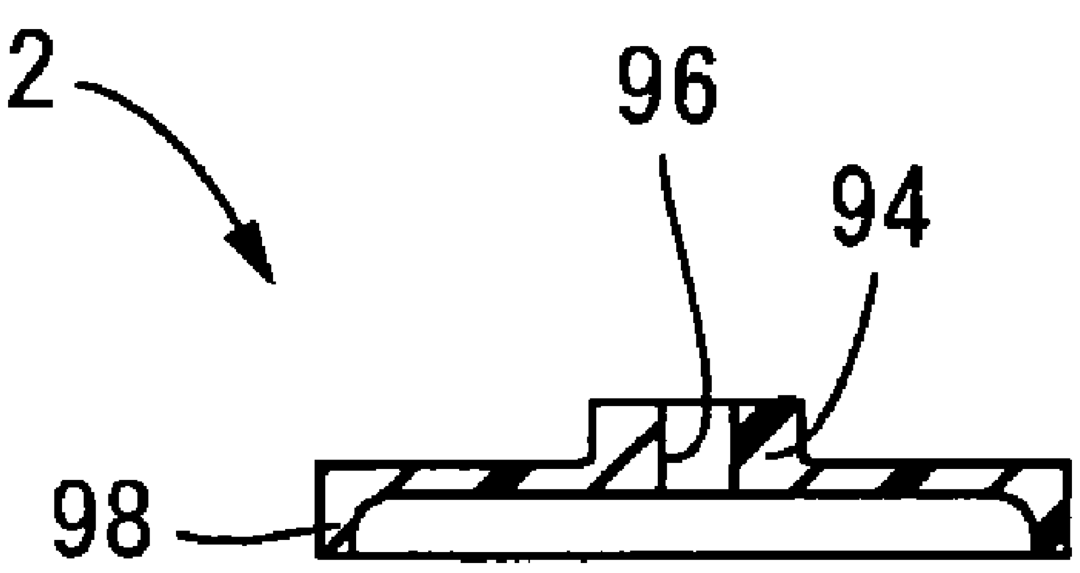

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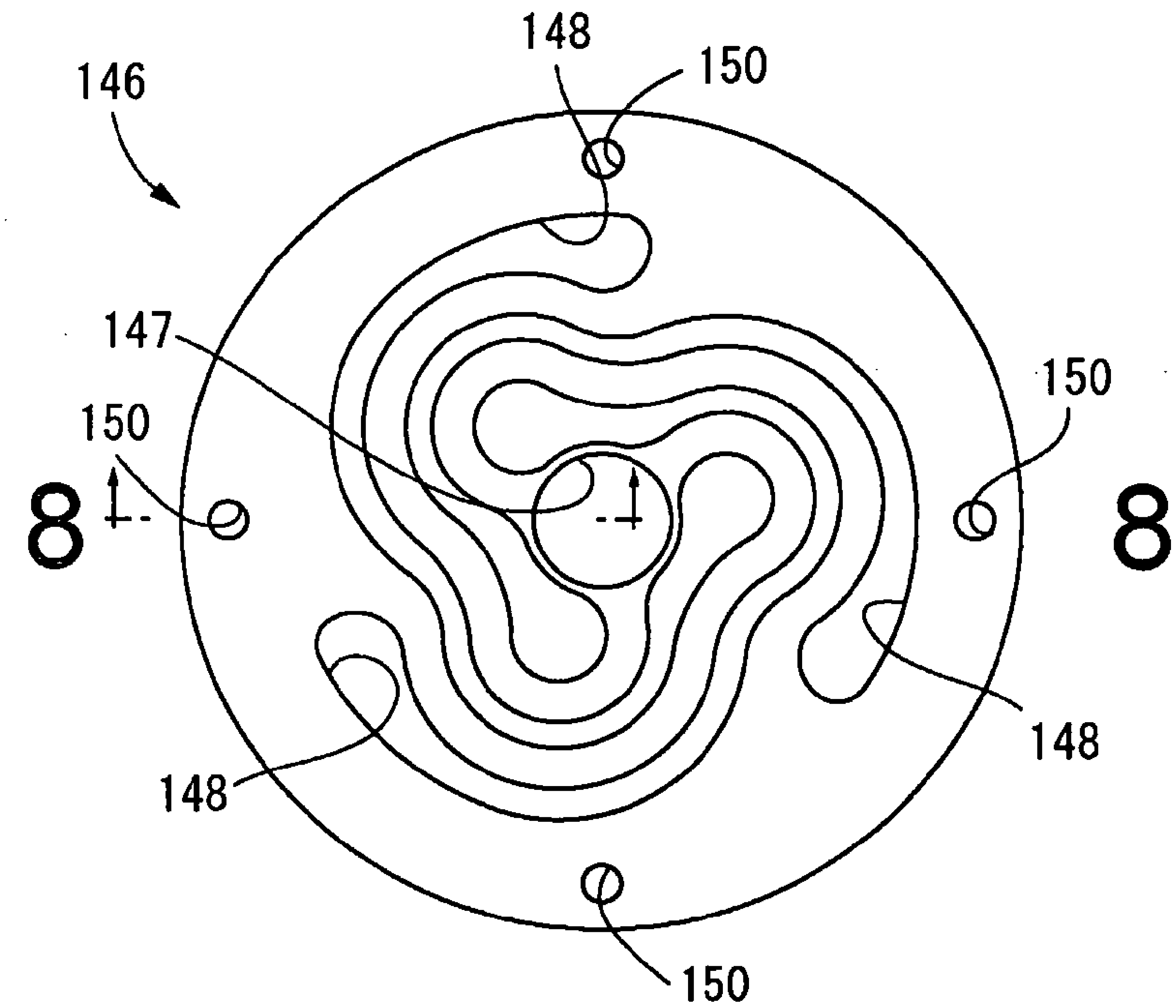

FIG.8

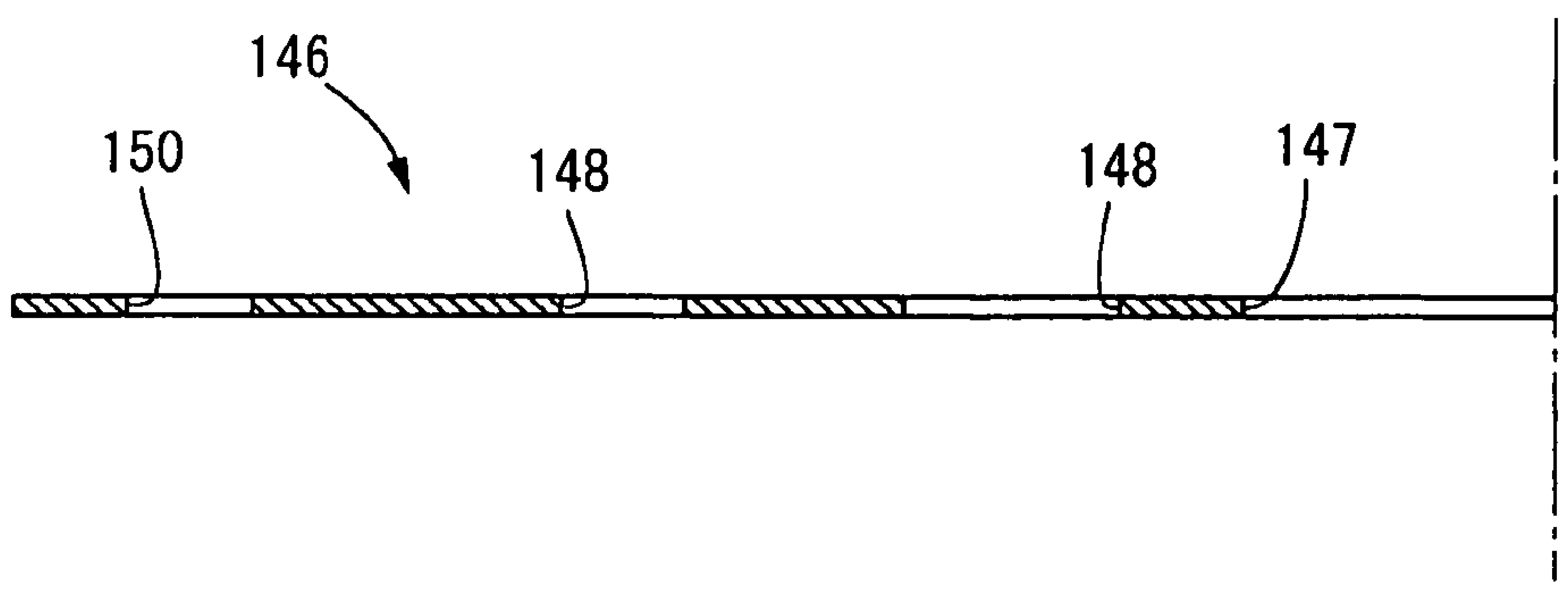

FIG.9

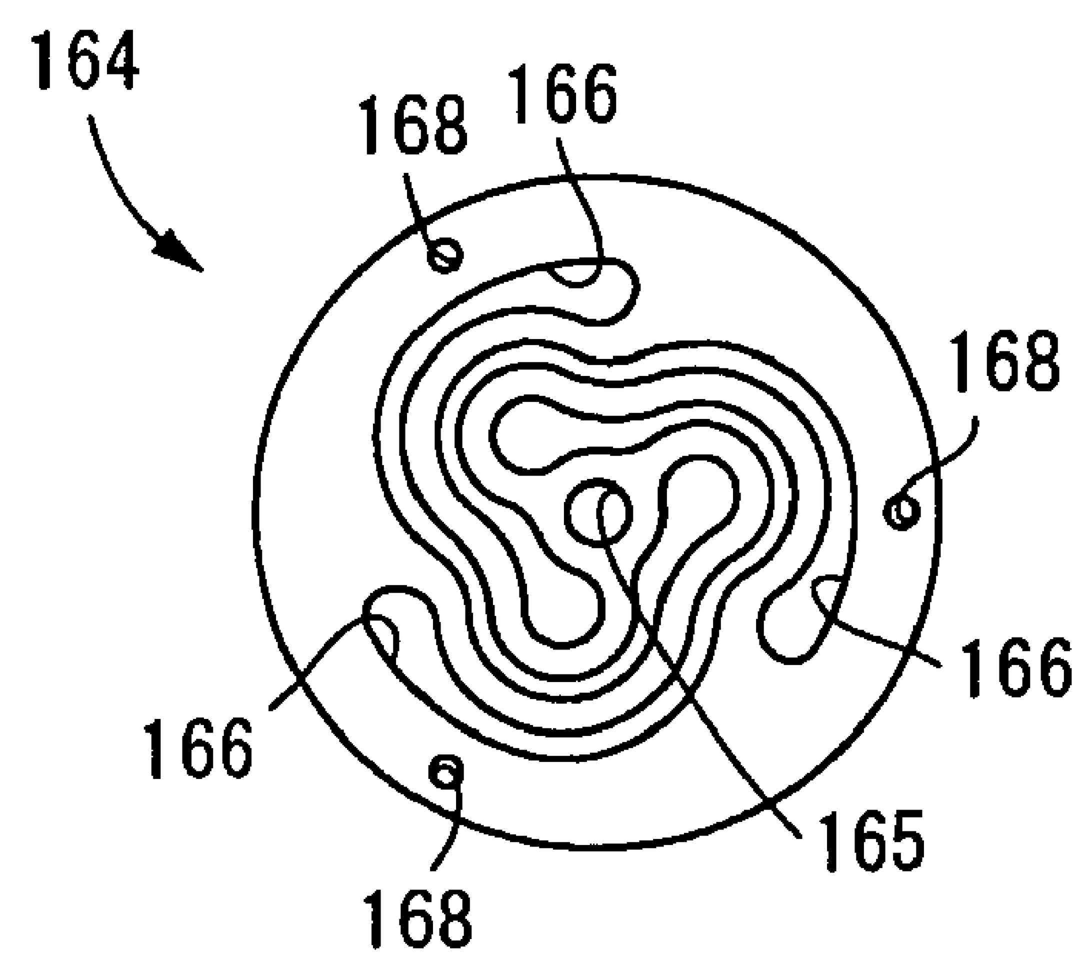
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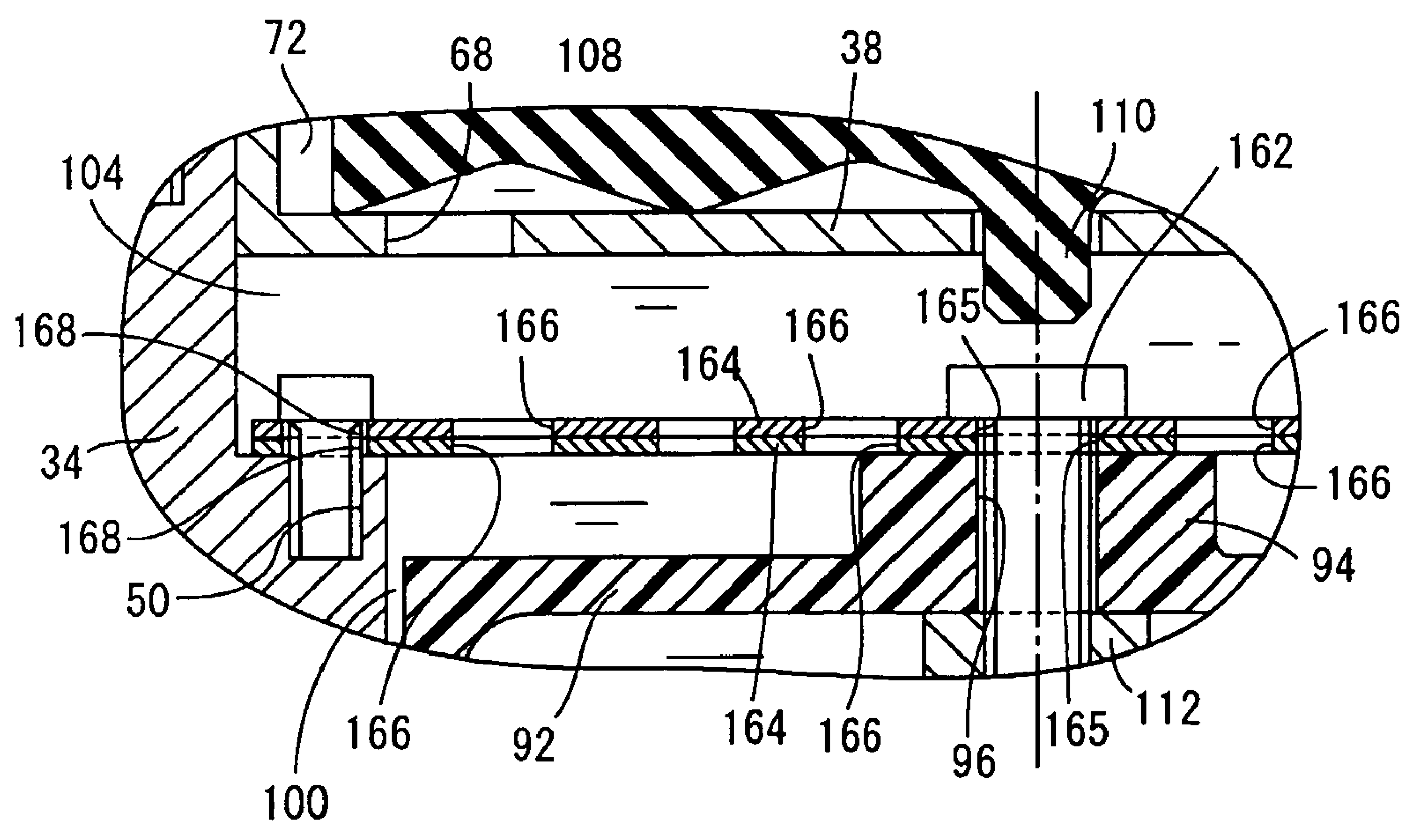
FIG.10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FLUID FILLED TYPE VIBRATION DAMPING DEVICE

INCORPORATED BY REFERENCE

The disclosure of Japanese Patent Application No. 2007-246119 filed on Sep. 21, 2007 and No. 2007-337015 filed on Dec. 27, 2007, each including the specification, drawings and abstract are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a fluid filled vibration damping device adapted to provide active vibration damping action through control of pressure fluctuations of a pressure receiving chamber that is filled with a non-compressible fluid, the control being carried out in a cycle that corresponds to the frequency of the vibration to be damped.

2. Description of the Related Art

In the field of vibration damping devices such as vibration damping linkages or vibration damping supports designed for installation between components that make up a vibration transmission system, one type of known device is a fluid filled type vibration damping device having a first mounting member and a second mounting member linked by a rubber elastic body; a pressure-receiving chamber whose wall is partially defined by the rubber elastic body and an equilibrium chamber whose wall is partially defined by a flexible film, the pressure-receiving chamber and the equilibrium chamber being formed to either side of a partition member and filled with a non-compressible fluid; and an orifice passage connecting the pressure-receiving chamber and the equilibrium chamber. Since this type of fluid filled vibration damping device is able to exhibit vibration damping effect by using flow action, e.g. resonance action, of fluid flowing through the orifice passage, application of such devices in automotive engine mounts and the like is a current topic of interest.

Active type fluid filled vibration damping devices are one type of fluid filled vibration damping device as discussed above. In such an active vibration damping device, typically, another part of the wall of the pressure-receiving chamber will be constituted by an oscillating plate, and an electromagnetic actuator will be disposed to the opposite side of the pressure-receiving chamber, with the oscillating plate between them. A coil member making up part of the electromagnetic actuator is fixedly supported on the second mounting member, and an output member that is subjected to driving force when electrical current is supplied to the coil member is affixed to the oscillating plate. With this arrangement, oscillation by the oscillating plate is actuated through control of current to the coil member with reference to the vibration to be damped, in order to control the vibration damping performance through control of pressure in the pressure-receiving chamber.

The oscillating plate employed in an active vibration damping device of this kind will in some instances be formed from a rubber elastic body for example. However, in order to ensure an effective piston surface area, it is preferable for the plate to be composed of a rigid member of metal, synthetic resin, or the like, as taught in U.S. Pat. No. 6,422,546.

However, in the fluid filled vibration damping device disclosed in U.S. Pat. No. 6,422,546, with the aim of providing the oscillating plate with elastically positioned support while ensuring fluid-tightness on the part of the pressure-receiving chamber, the oscillating plate is linked to the second mounting member via a supporting rubber elastic body of annular shape. For this reason, there is a anxiety that, owing to permanent set in fatigue of the supporting rubber elastic body, it will be difficult to consistently achieve the desired vibration damping action. Another problem is that oscillation energy of the oscillating plate will be consumed through deformation of the supporting rubber elastic body, and thus power consumption will be high.

Accordingly, in Japanese unexamined Patent Publication No. JP-A-2005-291276, the Applicant proposed a fluid filled vibration damping device incorporating an oscillating plate of piston design. In this fluid filled vibration damping device, a portion of the wall of the pressure-receiving chamber is defined by a cylinder member of hollow round tubular shape, and the output member of the electromagnetic actuator is provided at the distal end thereof in the actuation direction with an oscillating plate of piston shape. A gap is provided between the outside peripheral face of the oscillating plate and the inside peripheral face of the cylinder member, while the oscillating plate is displaceable in the axial direction along the inside peripheral face of the cylinder member. Through appropriate design of the planar dimensions and of the gap between the inside peripheral face of the cylinder member and the outside peripheral face of the oscillating plate, it is possible to control pressure of the pressure-receiving chamber in association with oscillation of the oscillating plate, while ensuring that pressure fluctuations of the pressure-receiving chamber are such that the orifice effect is maintained.

The gap between the inside peripheral face of the cylinder member and the outside peripheral face of the oscillating plate will be sufficiently small so as to inhibit pressure leakage from the pressure-receiving chamber through the gap. Additionally, in order to ensure large planar dimensions of the opposed faces of the oscillating plate and the cylinder member with a view to inhibiting pressure leakage from the pressure-receiving chamber, it will be preferable for the inside peripheral section of the cylinder member and of the outside peripheral section of the oscillating plate to have considerable axial length.

However, where the gap between the cylinder member and the oscillating plate is small and their opposed faces extend for considerable length in the axial direction, there is an anxiety that the oscillating plate will interfere with the inside peripheral face of the cylinder member.

In particular, owing to factors such as the pressure distribution of the pressure-receiving chamber and twisting displacement of the actuator output shaft, the oscillating plate will tend to interfere with the cylinder inside face through twisting displacement in the axial direction. When the oscillating plate experiences displacement in the axial direction while interfering with the cylinder member in this way, not only will the actuation efficiency of the oscillating plate be reduced, but there will also be an anxiety of damage to the opposing faces of the oscillating plate and/or the cylinder member. Furthermore, if seizing should occur, there is an anxiety that electromagnetic actuator may operate improperly of become non-operational, or that noise and vibration may result.

SUMMARY OF THE INVENTION

It is therefore one object of this invention to provide a fluid filled type active damping device of novel construction which affords stable driving displacement of the oscillating plate, and thereby achieves effective vibration damping action.

The above and/or optional objects of this invention may be attained according to at least one of the following modes of the invention. The following modes and/or elements employed in each mode of the invention may be adopted at any possible optional combinations. It is to be understood that the principle of the invention is not limited to these modes of the invention and combinations of the technical features, but may otherwise be recognized based on the teachings of the present invention disclosed in the entire specification and drawings or that may be recognized by those skilled in the art in the light of the present disclosure in its entirety.

A principle of the present invention provides a fluid filled type vibration damping device including: a rubber elastic body elastically connecting a first mounting member and a second mounting member, a partition member supported on the second mounting member; a pressure-receiving chamber whose wall is partly defined by the rubber elastic body; an equilibrium chamber whose wall is partly defined by a flexible film; the pressure-receiving chamber and the equilibrium chamber being formed to either side of the partition member and filled with a non-compressible fluid; a first orifice passage connecting the pressure-receiving chamber and the equilibrium chamber; an oscillating plate defining another part of the wall of the pressure-receiving chamber; and an electromagnetic actuator for actuating oscillation of the oscillating plate. The oscillating plate is constituted by including a cylinder shaped hole having a round tubular inside peripheral face formed in the partition member, and a piston shaped plate accommodated within the cylinder shaped hole with a gap provided between an outside peripheral face of the piston shaped plate and the inside peripheral face of the cylinder shaped hole so that the piston shaped plate is axially displaceable within the cylinder shaped hole, an output member of the electromagnetic actuator is passed through the flexible film and linked to the piston shaped plate, and a plate spring extending in an axis-perpendicular direction is disposed to an opposite side from the electromagnetic actuator with the piston shaped plate therebetween, with the oscillating plate being elastically linked to and supported in an axial direction with respect to the partition member by the plate spring.

In the fluid filled vibration damping device constructed according to the present invention, the oscillating plate at a first side thereof in the axial direction is positioned and supported in the axis-perpendicular direction by the output member of the electromagnetic actuator; and at the other side thereof in the axial direction is positioned and supported in the axis-perpendicular direction by the plate spring. By positioning and supporting the oscillating plate in the axis-perpendicular direction from both sides in the axial direction with respect to the partition member in this way, it is possible to achieve excellent suppressant effect against displacement of the oscillating plate in the axis-perpendicular direction, as well as against displacement in twisting directions.

That is, because the oscillating plate is substantially supported at both sides of its center axis (both sides in the actuation direction of the oscillating plate), the oscillating plate is positioned in proximity to a band of smaller displacement of the medial section rather than at the location of larger displacement of the free end side during tilting of the oscillating plate. For this reason, in addition to displacement in the axis-perpendicular direction, twisting deformation of the oscillating plate will be effectively inhibited as well, preventing it from interfering with the cylinder shape hole.

Moreover, because the oscillating plate is substantially supported at both sides of its center axis, problems caused by interference of the oscillating plate with the cylinder shaped hole can be resolved, while the gap between the outside peripheral face of the oscillating plate (which is constituted by the piston shaped plate) and the inside peripheral face of the cylinder shaped hole can be made sufficiently small, and the opposing sections of the piston shaped plate and the cylinder shaped hole can be given sufficient axial length. The effective planar dimensions of the piston shaped plate may be increased thereby, and pressure leakage from the pressure-receiving chamber through the gap may be suppressed, thereby affording efficient and stable pressure control of the pressure-receiving chamber.

Moreover, by making possible a smaller gap between the piston shaped plate and the cylinder shaped hole and greater axial length of the gap, the flow resistance of fluid through the gap can be elevated, preventing pressure fluctuations of the pressure-receiving chamber from escaping into the equilibrium chamber through the gap. This results in effectively producing passive vibration damping action as well.

Furthermore, owing to the use of the plate spring in the present invention, the oscillating plate is allowed to undergo adequate displacement in the axial direction, while at the same time being effectively positioned in the axis-perpendicular direction. Moreover, since the dimension of the plate spring in the axial direction is typically small, it will be possible to avoid problems in terms of ensuring adequate space or larger size in association with installation of the plate spring in the vibration damping device.

According to one preferred mode of the fluid filled vibration damping device of the present invention, the electromagnetic actuator may employ a design whereby the output member is elastically supported with respect to a housing of the electromagnetic actuator by a supporting plate spring that extends in the axis-perpendicular direction. With this arrangement, greater stability of the output member which has been positioned in the axis-perpendicular direction by the supporting plate spring can be utilized to achieve a higher level of reliability in positioning of the oscillating plate in the axis-perpendicular direction.

According to another possible mode of the fluid filled vibration damping device of the present invention, wherein the pressure-receiving chamber is partitioned by a dividing wall member that is disposed in a medial section of the pressure-receiving chamber in order to form to either side of the dividing wall member a first pressure-receiving chamber whose wall is partly defined by the rubber elastic body and a second pressure-receiving chamber whose wall is partly defined by the oscillating plate, and a filter orifice is provided for connecting the first pressure-receiving chamber and the second pressure-receiving chamber. Specifically, in the first pressure-receiving chamber, pressure fluctuations will be produced directly on the basis of elastic deformation of the rubber elastic body at times of input of vibration, whereas the second pressure-receiving chamber will be exposed to pressure fluctuations of the first pressure-receiving chamber through the filter orifice, giving rise to pressure fluctuations in association with input of vibration. Here, where the resonance frequency of fluid flowing through the filter orifice is tuned to the frequency range of problematical vibration that has been targeted for active vibration damping action by the oscillating plate, pressure fluctuations arising in the second pressure-receiving chamber on the basis of actuated oscillation of the oscillating plate will be transmitted efficiently to the first pressure-receiving chamber, utilizing the resonance action etc. of fluid through the filter orifice. The pressure-receiving chamber composed of this first pressure-receiving chamber and second pressure-receiving chamber can thereby be positively and actively controlled, and the desired vibration damping action may be attained with a higher level of effectiveness.

According to yet another possible mode of the fluid filled vibration damping device of the present invention, a second orifice passage is provided connecting the second pressure-receiving chamber and the equilibrium chamber, with the second orifice passage being tuned to a higher frequency range than the first orifice passage, the filter orifice is formed in the dividing wall member, and a movable plate is displaceably disposed in the filter orifice such that pressure of the first pressure-receiving chamber is exerted on a first face of the movable plate while pressure of the second pressure-receiving chamber is exerted on another face of the movable plate. With this arrangement, at times of input of vibration lying in the tuning frequency range of the first orifice passage, the opening of the second oscillating plate on the pressure-receiving chamber side thereof is covered by the movable plate, thus preventing pressure leakage from the pressure-receiving chamber through the second orifice passage and ensuring a sufficient level of fluid flow through the first orifice passage. As a result, vibration damping action based on resonance action of fluid through the first orifice passage will be consistently achieved. Also, at times of input of vibration lying in the tuning frequency range of the second orifice passage, even if the first orifice passage (which has been tuned to a lower frequency range than the second orifice passage) becomes substantially closed off, a sufficient level of fluid flow through the second orifice passage will be ensured on the basis of displacement of the movable plate due to the relative pressure differential between the first pressure-receiving chamber and the second pressure-receiving chamber. Consequently, vibration damping action based on resonance action of fluid through the second orifice passage will be effectively achieved.

Specifically, according to this mode, vibration damping action against vibration of multiple frequency ranges will be effectively afforded based on the flow action, e.g. resonance action, of fluid flowing respectively through the first orifice passage and the second orifice passage. In particular, since the movable plate is disposed in the filter orifice, the movable plate and the filter orifice that is tuned to a higher frequency range than the resonance frequency of the second orifice passage may be realized through a relatively simple structure. Additionally, sufficient space for installing the movable plate will be effectively ensured thereby achieving both improved vibration damping performance and smaller size of the vibration damping device.

The movable plate according to this mode may employ any of a number of designs that regulate pressure fluctuations by inducing displacement of the plate based on a relative pressure differential between the first pressure-receiving chamber and the second pressure-receiving chamber. For example, as taught inter alia in Japanese Unexamined Patent Publication No. JP-A-01-93638, U.S. Pat. No. 7,322,570, or Japanese Unexamined Patent Publication No. JP-A-2006-97823, the movable plate may be positioned held in an unattached state within a prescribed holding area so as to be finely displaceable in the thickness direction within the holding area. Thus, via holes formed in the holding area, pressure of the first pressure-receiving chamber is exerted on one face of the movable plate while pressure of the second pressure-receiving chamber is exerted on the other face of the movable plate, whereby a relative pressure differential between the first pressure-receiving chamber and the second pressure-receiving chamber will be absorbed on the basis of fine displacement of the movable plate within the holding area, and pressure absorption by the movable plate in excess of an allowable displacement level will be prevented. Alternatively, it would be possible to employ a design as taught inter alia in Japanese Unexamined Patent Publication Nos. JP-A 2000-213586, JP-A-07-71506, or JP-A-11-101294 for example, wherein at least the outside peripheral section of the movable plate is defined by a partition rubber elastic plate, with the partition rubber elastic plate being attached at its outside peripheral edge to the partition member or to the second mounting member thereby fluid-tightly partitioning the first pressure-receiving chamber and the second pressure-receiving chamber so that a relative pressure differential arising between the first pressure-receiving chamber and the second pressure-receiving chamber and exerted on the respective faces of the partition rubber elastic plate will be absorbed on the basis of elastic displacement and/or elastic deformation of the partition rubber elastic plate based on this pressure differential between the first pressure-receiving chamber and the second pressure-receiving chamber, while at the same time preventing large pressure absorption through elastic deformation of the partition rubber elastic plate. Alternatively, it would be possible to employ a design as taught in U.S. Pat. No. 7,188,830, whereby a plurality of elastic projecting portions are disposed on both faces of the movable plate, and the movable plate is constrained in localized fashion by means of these elastic projecting portions being held clasped between the walls of the holding area of the movable plate, with the spaces between the walls of the holding area and those sections of the movable plate devoid of elastic projecting portions defining fluid channels that connect the first pressure-receiving chamber and the second pressure-receiving chamber with one another.

According to yet another possible mode of the fluid filled vibration damping device of the present invention, the cylinder shaped hole is formed in a center section of the partition member so as to extend in a direction of opposition of the pressure-receiving chamber and the equilibrium chamber, with the wall of the equilibrium chamber being defined in part by an outside peripheral section of the partition member about the cylinder shaped hole, and an outside peripheral face of the partition member has a tapering contour decreasing in diameter from a first axial end of a pressure-receiving chamber side thereof towards another axial end on an equilibrium chamber side. According to this mode, variable capacity of the flexible film in the equilibrium chamber will be efficiently ensured, and freedom in design of the flexible film will be improved, thereby affording further improvement in tuning of the desired vibration damping action.

According to yet another possible mode of the fluid filled vibration damping device of the present invention, a plurality of plate springs are disposed in a stacked structure by being juxtaposed in a direction of actuation of the oscillating plate. Specifically, while one conceivable method for increasing the oscillation frequency of the oscillating plate would be to increase the thickness dimension of the plate spring to make it more rigid for example, making the plate spring thicker in this way will tend to result in higher stress and significant strain. In a plate spring, which experiences appreciable metal fatigue due to repeated elastic deformation experienced during actuation of the oscillating plate, it is important to minimize strain in order to ensure endurance. Accordingly, as taught in this mode, where a stacked structure composed of a plurality of juxtaposed plate springs is employed, the plate spring can be made more rigid while at the same time reducing stress transmission and avoiding significant strain. For this reason, enduring performance of the oscillating plate may be ensured, while further improving the degree of freedom in tuning of the oscillation frequency.

According to still another possible mode of the fluid filled vibration damping device of the present invention, a lightening section is formed in each plate spring, and a plurality of plate springs are juxtaposed with the lightening sections communicating with one another. By so doing, a zone between the plate springs and the oscillating plate will communicate via the lightening sections with a fluid-filled zone whose wall is partly defined by the rubber elastic body. For this reason, the pressure-receiving chamber can be constituted by a zone between the plate springs and the oscillating plate in addition to the fluid-filled zone to the inside of the rubber elastic body, thereby effectively ensuring adequate capacity of the pressure-receiving chamber. Moreover, when the plate springs induce elastic deformation within the pressure-receiving chamber, the fluid resistance of the plate springs will be lower due to the presence of the lightening sections, thereby reducing energy loss associated with deforming of the plate springs, and hence with actuating oscillation of the oscillating plate. Furthermore, since the spring characteristics of the plate springs can now be tuned through appropriate design modification of the shape, size, number etc. of the lightening sections in addition to design modification of the shape, size, etc. of the plate springs, a higher degree of freedom in tuning of spring characteristics is afforded thereby.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and/or other objects, features and advantages of the invention will become more apparent from the following description of a preferred embodiment with reference to the accompanying drawings in which like reference numerals designate like elements and wherein:

FIG. **1** is a vertical cross sectional view of a fluid filled type vibration damping device in the form of an automotive engine mount according to one embodiment of the present invention;

FIG. **2** is a top plane view of a partition member of the engine mount of FIG. **1**;

FIG. **3** is a cross sectional view taken along line **3-3** of FIG. **2**;

FIG. **4** is a top plane view of a partition member body of FIG. **2**;

FIG. **5** is a top plane view of an oscillating plate of the engine mount of FIG. **1**;

FIG. **6** is a cross sectional view of the oscillating plate taken along line **6-6** of FIG. **5**;

FIG. **7** is a top plane view of a supporting plate spring of the engine mount of FIG. **1**;

FIG. **8** is an enlarged cross sectional view taken along line **8-8** of FIG. **7**;

FIG. **9** is a top plane view of a part of a plate spring of the engine mount of FIG. **1**; and

FIG. **10** is an enlarged view in vertical cross section of a part of an engine mount of construction according to another embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to FIG. **1**, there is depicted an automotive engine mount **10** according to one embodiment of a fluid-filled type vibration damping device of the present invention. This engine mount **10** has a construction wherein a first mounting member **12** of metal and a second mounting member **14** of metal are linked by a main rubber elastic body **16**. The first mounting member **12** is adapted to be mounted onto the vehicle's power unit (not shown), and the second mounting member **14** is adapted to be mounted onto an automobile body (not shown). The power unit is thereby elastically supported on the vehicle body via the intervening engine mount **10**.

Whereas FIG. **1** depicts the engine mount **10** in isolation prior to installation in a vehicle, with the engine mount **10** installed in the vehicle, distributed load of the power unit will be input in the mount axial direction (the vertical direction in FIG. **1**), thereby inducing displacement of the first mounting member **12** and the second mounting member **14** in the direction closer together in the mount axial direction, whereupon the main rubber elastic body **16** elastically deforms. In this installed state, principle vibration targeted for damping will be input approximately in the mount axial direction. In the description hereinbelow, unless indicated otherwise, vertical direction refers to the vertical direction in FIG. **1**.

More specifically, the first mounting member **12** has an inverted bottomed round tubular shape or round post shape. A screw hole **18** which opens onto the upper end face is provided in the center section of the first mounting member **12**. The first mounting member **12** is attached securely to the power unit by screw-fastening a member on the power unit side (not shown) to the screw hole **18** using a fastening bolt.

The second mounting member **14** has a large-diameter, generally stepped round tubular shape, with a small-diameter portion **22** extending upward from the inside peripheral edge of a shoulder portion **20** of annular plate shape, and a large-diameter portion **24** extending downward from the outside peripheral edge of the shoulder portion **20**. The axial dimension of the small-diameter portion **22** is longer than the axial dimension of the large-diameter portion **24**.

The first mounting member **12** and the second mounting member **14** are positioned coaxially with one another, with the first mounting member **12** positioned facing at a prescribed distance away in the axial direction the opening at the small-diameter portion **22** end of the second mounting member **14**. The main rubber elastic body **16** is interposed between the first mounting member **12** and the second mounting member **14**.

The main rubber elastic body **16** is a thick rubber elastic body of generally truncated conical shape. In the center portion of the lower end of the main rubber elastic body **16**, there is formed a large-diameter recess **26** of inverted conical or semispherical shape opening downward. A section of the first mounting member **12** extending to its lower end from its axially medial portion is vulcanization bonded to the upper end of the main rubber elastic body **16** so as to be embedded therein, while the inside peripheral face of the small-diameter portion **22** of the second mounting member **14**, at a section thereof extending to its axially medial portion from its upper end section, is juxtaposed against and vulcanization bonded to the outside peripheral face of the lower end of the main rubber elastic body **16**. The main rubber elastic body **16** is thereby constituted as an integrally vulcanization molded component that integrally incorporates the first mounting member **12** and the second mounting member **14**, and one of the openings of the second mounting member **14** (at top in FIG. **1**) is sealed off fluid-tightly by the main rubber elastic body **16**. The inside peripheral face of the small-diameter portion **22** of the second mounting member **14** is sheathed entirely from its axially medial section to its lower end section by a thin rubber seal layer **28** that is integrally formed with the main rubber elastic body **16**. The rim of the open end of the large-diameter recess **26** in the main rubber elastic body **16** is situated inward in the axis-perpendicular direction from the inside peripheral face of the rubber seal layer **28**, so that an annular step portion **30** of annular shape is formed in the boundary section between the main rubber elastic body **16** and the rubber seal layer **28**.

A partition member **32** is attached in the opening section of the second mounting member **14** on its axial lower side. The partition member **32** overall has a generally round block shape, and includes a partition member body **34**, a first dividing wall plate **36** and a second dividing wall plate **38**. In this embodiment, the partition member **32** is made of metal material such as aluminum alloy or steel, but it could also be made from rigid synthetic resin material or the like.

As depicted in FIGS. **2** to **4** as well, an outer flanged portion **40** of large-diameter annular shape is integrally formed at the upper edge section of the partition member body **34**. The outside peripheral face of the partition member body **34** has a tapered shape gradually decreasing in outside diameter dimension from top to bottom.

A circular center hole **42** is formed extending in the axial direction through the center section of the partition member body **34** so as to penetrate the upper and lower end faces of the partition member body **34**. A step portion **44** of annular shape is formed in the peripheral wall of the center hole **42** in its generally axial center section, with the diameter dimension of the center hole **42** in its upper section to one side of the step portion **44** being larger compared to the diameter dimension in its lower section. A cylinder shaped hole **46** according to this embodiment is defined by this lower section of the center hole **42**. An inner flanged portion **48** is integrally formed at the lower opening section of the cylinder shaped hole **46**. A plural number of screw holes **50** are disposed prescribed distances apart in the circumferential direction, in the step portion **44** and around the upper rim of the center hole **42**. The diametrically medial section or outer peripheral section of the outer flanged portion **40** is perforated in the thickness direction (the vertical in FIG. **1**) by a connecting window **52**. As will be apparent from the above description, the cylinder shaped hole **46** is formed so as to extend in the axial direction through the center section of the partition member **32** (the partition member body **34**), and the outer peripheral section of the partition member **32** around the cylinder shaped hole **46** is defined by a tapered shape of decreasing diameter from a first axial end (at top in FIG. **1**) to the other.

A block shaped portion **54** is disposed projecting diametrically outward from a single location along the circumference of the peripheral wall section of the partition member body **34**, and a connecting passage **56** extends in tunnel form through the block shaped portion **54**. The connecting passage **56** extends continuously with unchanging oblong cross section in the diametrical direction through the partition member body **34**, with a first end (face) thereof opening onto the peripheral wall face of the center hole **42** of the partition member body **34** at a location above the step portion **44**, and with the other end (face) opening onto the diametrically outward end face of the block shaped portion **54**.

The first dividing wall plate **36** has a shallow, generally circular saucer shape whose base portion is penetrated by through-holes **58** composed of a plurality of small holes; and a rimming portion **60** of annular shape is integrally formed at its upper lip. The rimming portion **60** extends parallel to the base portion of the first dividing wall plate **36**, at a location above the base portion. The outside diameter dimension of the base portion of the first dividing wall plate **36** is large in comparison with the diameter dimension of the large-diameter section at the upper side of the center hole **42** of the partition member body **34**, and insertion holes **64** are formed penetrating the outside peripheral section of the base portion at locations corresponding to the screw holes **50** of the partition member body **34**.

Meanwhile, the second dividing wall plate **38** has a shallow, generally bottomed cylindrical shape, with a large-diameter outer flanged portion **66** formed at the lip of the opening. In other words, the second dividing wall plate **38** has the form of a thin circular disk shape with a circular recess formed in its center section. The outside diameter dimension of the outer flanged portion **66** is approximately identical to the outside diameter dimension of the outer flanged portion **40** of the partition member body **34**, and is larger in comparison with the outside diameter dimension of the rimming portion **60** of the first dividing wall plate **36**. The outside diameter dimension of the peripheral wall of the second dividing wall plate **38** is slightly smaller than the diameter dimension of the large-diameter section at the upper side of the center hole **42** of the partition member body **34**. Furthermore, the axial length of the peripheral wall of the second dividing wall plate **38** is smaller in comparison with the axial length of the large-diameter section. Through-holes **68** composed of a plurality of small holes are formed penetrating the base portion of the second dividing wall plate **38**. Additionally, insertion holes **70** are formed penetrating the diametrically medial section or inside peripheral section of the outer flanged portion **66**, at locations corresponding to the screw holes **50** of the partition member body **34** and to the insertion holes **64** of the first dividing wall plate **36**.

The peripheral wall of the second dividing wall plate **38** is slipped into the upper opening section of the center hole **42** of the partition member body **34**, and the outer flanged portion **66** of the second dividing wall plate **38** is juxtaposed against the outer flanged portion **40** of the partition member body **34**. Furthermore, the outside peripheral section of the base of the first dividing wall plate **36** is juxtaposed against the diametrical inside peripheral section or medial section of the outer flanged portion **66** of the second dividing wall plate **38**, while the screw holes **50** of the partition member body **34**, the insertion holes **70** of the second dividing wall plate **38**, and the insertion holes **64** of the first dividing wall plate **36** are aligned overlapping one another in the axial direction. Fastening bolts are then passed through the insertion holes **64**, **70** in the first and second dividing wall plates **36**, **38**, and fastened by screwing into screw holes **50** of the partition member body **34**. The partition member **32** constituted thereby has a form in which the upper opening of the center hole **42** of the partition member body **34** has been covered by the first and second dividing wall plates **36**, **38**. The base portion of the second dividing wall plate **38** and the step portion **44** of the center hole **42** in the partition member body **34** are now positioned in opposition a prescribed distance apart in the axial direction.

The rimming portion **60** of the first dividing wall plate **36** and the outer flanged portion **66** of the second dividing wall plate **38** are positioned in opposition a prescribed distance apart in the axial direction, with the lower end face of the rimming portion **60**, the outside peripheral face of the peripheral wall of the first dividing wall plate **36**, and the upper end face of the outer flanged portion **66** cooperating to define a peripheral groove **62** having a cross section that opens with slot contours diametrically outward in the outside peripheral section of the partition member **32**, and extends continuously all the way around its circumference.

Furthermore, by covering the opening section of the second dividing wall plate **38** with the base portion of the first dividing wall plate **36**, a circular zone **72** that extends with generally unchanging circular cross section in the axial direction is formed between the center of the base portion of the first dividing wall plate **36** and the center portion of the second dividing wall plate **38**.

The partition member **32** of the above design is inserted in the axial direction into the second mounting member **14** from its bottom opening, and the rimming portion **60** of the first dividing wall plate **36** is juxtaposed against the annular step portion **30** of the main rubber elastic body **16**, while the outside peripheral section of the outer flanged portion **66** of the second dividing wall plate **38** is juxtaposed against the shoulder portion **20** via the intervening rubber seal layer **28** of the second mounting member **14**. With this arrangement, the inserted end of the partition member **32** in the axial direction is regulated with respect to the second mounting member **14**.

A diaphragm **74** (the flexible film) is disposed below the partition member **32**. The diaphragm **74** is formed from a thin circular rubber film having ample slack. A fastener fitting **76** is vulcanization bonded to the outside peripheral edge of the diaphragm **74**. The fastener fitting **76** has a design with an inner flanged portion that projects diametrically inward integrally disposed at the lower end section of a large-diameter ring. The diaphragm **74** is vulcanization bonded at its outside peripheral edge to the inside peripheral edge of the fastener fitting **76**, while a thin seal rubber layer **78** that is integrally formed with the diaphragm **74** is vulcanization bonded over generally the entire inside peripheral face of the fastener fitting **76**.

The fastener fitting **76** is, slipped inside the second mounting member **14** in the axial direction from the opening on its lower side (the large-diameter portion **24** side), and the upper edge of the fastener fitting **76** is then juxtaposed in the axial direction against the inside peripheral section of the shoulder portion **20** of the second mounting member **14** via the intervening seal rubber layer **78**, while the inside peripheral edge on the lower side of the fastener fitting **76** is juxtaposed in the axial direction against the outside peripheral section of the outer flanged portion **40** of the partition member body **34** via the intervening seal rubber layer **78**.

Further, a bracket member **80** of round tubular shape is fastened fitting externally about the second mounting member **14**. This bracket member **80** is utilized to fasten the partition member **32** and the diaphragm **74** to the second mounting member **14**. Specifically, the bracket member **80** includes a middle tube fitting **82** having a thick-walled generally round tubular shape and end plate fittings **84*a***, **84*b*** of annular plate shape that are juxtaposed against the axial ends of the middle tube fitting **82**. The fittings **82**, **84*a***, **84*b*** are mated in the axial direction and fastened together with bolts. With the shoulder portion **20** of the second mounting member **14** and the fastener fitting **76** of the diaphragm **74** inserted axially between the upper end plate fitting **84*a*** and the middle tube fitting **82**, the bracket member **80** is fastened to the second mounting member **14** by bolting together the end plate fitting **84*a*** and the middle tube fitting **82**. In association with bolting together the end plate fitting **84*a*** and the middle tube fitting **82**, the shoulder portion **20** of the second mounting member **14** and the fastener fitting **76** is positioned clamped in the axial direction, with the rimming portion **60** of the first dividing wall plate **36** and the annular step portion **30** of the main rubber elastic body **16**, the outside peripheral section of the outer flanged portion **66** of the second dividing wall plate **38** and the diametrically inside peripheral section or medial section of the shoulder portion **20** of the second mounting member **14**, and the upper end section of the fastener fitting **76** and the outside peripheral section of the shoulder portion **20** respectively juxtaposed fluid-tightly via the intervening rubber seal layers **28**, **78** etc. By so doing, through fastening of the bracket member **80** to the second mounting member **14** the partition member **32** and the diaphragm **74** is fixedly attached to the second mounting member **14**, while the lower opening of the second mounting member **14** is blocked off fluid-tightly by the partition member **32** and the diaphragm **74**. By then fastening the bracket member **80** to a component on the vehicle body side (not shown), the second mounting member **14** is fixedly mounted onto the vehicle body.

By thusly attaching the partition member **32** and the diaphragm **74** to the integrally vulcanization molded component of the main rubber elastic body **16** incorporating the first and second mounting members **12**, **14**, a pressure-receiving chamber **86** whose wall is partly defined by the main rubber elastic body **16** and which gives rise to pressure fluctuations at times of vibration input is defined to a first axial side of the partition member **32** (at top in FIG. **1**), within the area of the large-diameter recess **26** of the main rubber elastic body **16** that has been blocked off by the partition member **32**. To the other axial side of the partition member **32** (at bottom in FIG. **1**) there will be formed an equilibrium chamber **88** whose wall is partly defined by the diaphragm **74** and which readily allows change in volume. The pressure-receiving chamber **86** and the equilibrium chamber **88** are filled with a non-compressible fluid. Water, an alkylene glycol, a polyalkylene glycol, silicone oil, or the like may be employed as the sealed non-compressible fluid, but with a view to effectively achieving vibration damping action based on flow action, e.g. resonance action, of the fluid, it is especially preferable to use a low-viscosity fluid of 0.1 Pa·s or lower. Sealing of the non-compressible fluid within the pressure-receiving chamber **86** and the equilibrium chamber **88** may be accomplished advantageously, for example, by attaching the partition member **32** and the diaphragm **74** to the main rubber elastic body **16** incorporating the first and second mounting members **12**, **14** while these components are submerged in the non-compressible fluid. From the above discussion it is appreciated that the wall of the equilibrium chamber **88** is partly defined by the tapered outside peripheral section of the partition member **32** (the partition member body **34**) around the cylinder shaped hole **46**.

In association with the partition member **32** being attached to the second mounting member **14**, the open section of the peripheral groove **62** of the partition member **32** is juxtaposed fluid-tightly against the inside peripheral face of the second mounting member **14** via the intervening rubber seal layer **28** that sheathes the second mounting member **14**, so that the peripheral groove **62** is closed off fluid-tightly. The inside peripheral face of the second mounting member **14** and the walls of the peripheral groove **62** are thereby cooperate to define a first orifice passage **90** that extends for a prescribed length in the circumferential direction through the outside peripheral section of the partition member **32**. A first end of this first orifice passage **90** connects to the pressure-receiving chamber **86** via a connecting window (not shown) that penetrates the peripheral wall of the first dividing wall plate **36**, while the other end of the first orifice passage **90** connects to the equilibrium chamber **88** through a connecting window penetrating the second dividing wall plate **38** and the connecting window **52** of the partition member body **34**, which windows have been aligned with one another in axial direction. The pressure-receiving chamber **86** and the equilibrium chamber **88** thereby communicate with each other through the first orifice passage **90**, allowing fluid flow between the two chambers **86**, **88** through the first orifice passage **90**.

An oscillating plate **92** composed of a piston shaped plate is disposed in the cylinder shaped hole **46** of the partition member **32**. As depicted in FIGS. **5** and **6**, the oscillating plate

92 has a thin, generally circular disk shape, and is made of rigid synthetic resin material, metal, or the like. A boss shaped projection 94 having a small-diameter cylindrical shape projects upward from the center section of the oscillating plate 92, and the borehole of the boss shaped projection 94 opens onto the lower end face of the oscillating plate 92 so that an insertion hole 96 is formed on the center axis of the oscillating plate 92. Additionally, a rim shaped projection 98 of generally round cylindrical shape is formed on the outside peripheral edge of the oscillating plate 92, projecting downward in the axial direction.

The oscillating plate 92 and the cylinder shaped hole 46 are arranged coaxially, with the rim shaped projection 98 of the oscillating plate 92 positioned along the peripheral wall of the cylinder shaped hole 46 of the partition member 32. The oscillating plate 92 is positioned in opposition to and a prescribed distance away in the axial direction from the base portion of the second dividing wall plate 38 which covers the upper opening of the center hole 42 of the partition member body 34. Here, small gap 100 is formed about the entire perimeter between the peripheral wall of the cylinder shaped hole 46 and the outside peripheral section of the oscillating plate 92 having the rim shaped projection 98, and due to the presence of this gap 100, an appropriate level of axial displacement of the oscillating plate 92 is allowed. While no particular limitation is imposed as to whether fluid flow etc. can arise through this gap 100, in this embodiment, the gap 100 is small enough that substantially no fluid flow etc. will take place through it. As a result, the lower opening of the center hole 42 of the partition member body 34 will be substantially blocked off by the oscillating plate 92.

The zone between the second dividing wall plate 38 and the oscillating plate 92 in the partition member 32 intercommunicates with the pressure-receiving chamber 86 through the through-holes 58, 68 that penetrate the first and second dividing wall plates 36, 38 and through the circular zone 72 between the first dividing wall plate 36 and the second dividing wall plate 38, and this zone is filled with the same non-compressible fluid as the pressure-receiving chamber 86. Specifically, through the through-holes 58, 68 and the circular zone 72 the zone between the oscillating plate 92 and the second dividing wall plate 38 is subject to pressure fluctuations arising in the pressure-receiving chamber 86, and thus the zone functions as part of the pressure-receiving chamber 86. As will be appreciated from the description above, in the pressure-receiving chamber 86, the oscillating plate 92 defines another part of the wall different from that defined by the main rubber elastic body 16.

In other words, to a first side of the first and second dividing wall plates 36, 38 (at top in FIG. 1) of the partition member 32, there is formed a first pressure-receiving chamber 102 whose wall is partly defined by the main rubber elastic body 16, while to the other side of the first and second dividing wall plates 36, 38 (at bottom in FIG. 1) of the partition member 32, there is formed a second pressure-receiving chamber 104 whose wall is partly defined by the oscillating plate 92. The pressure-receiving chamber 86 incorporates this first pressure-receiving chamber 102 and second pressure-receiving chamber 104 in its design. It will be appreciated from the above description that the dividing wall member dividing the pressure-receiving chamber 86 incorporates the first dividing wall plate 36 and the second dividing wall plate 38 in its design. Additionally, the filter orifice through which the first pressure-receiving chamber 102 and the second pressure-receiving chamber 104 intercommunicate incorporates the through-holes 58, 68 that have been formed in the first and second dividing wall plates 36, 38 and the circular zone 72 in its design.

In this embodiment in particular, the resonance frequency of fluid flowing through the filter orifice that incorporates the aforementioned through-holes 58, 68 and the circular zone 72 has been tuned to a high frequency range on the order of 80 to 100 Hz corresponding to medium- or high-speed rumble which has been targeted for active vibration damping by the oscillating plate 92.

The connecting passage 56 that has been formed in the partition member body 34 connects at a first end thereof to the second pressure-receiving chamber 104, while the other end of the connecting passage 56 connects to the equilibrium chamber 88. That is, the connecting passage 56 constitutes a second orifice passage 106 connecting the second pressure-receiving chamber 104 and the equilibrium chamber 88 to one another and allowing flow of fluid between the two chambers 88, 104 through the second orifice passage 106.

In this embodiment in particular, the resonance frequency of fluid flowing through the first orifice passage 90 is tuned, for example, so as to produce effective vibration damping action (high attenuating action) against vibration in a low-frequency range of about 10 Hz corresponding to engine shake, on the basis of resonance action of the fluid. Meanwhile, the resonance frequency of fluid flowing through the second orifice passage 106 is tuned, for example, so as to produce effective vibration damping action against vibration in a medium-frequency range of about 20 to 40 Hz corresponding to idling vibration or low speed rumble, on the basis of resonance action of the fluid. That is, the tuning frequency of the second orifice passage 106 is set to a higher frequency range than the tuning frequency of the first orifice passage 90, and the tuning frequency of the filter orifice defined by the aforementioned through-holes 58, 68 and the circular zone 72 is set to a higher frequency range than the first and second orifice passages 90, 106. Tuning of the first orifice passage 90, the second orifice passage 106, and the filter orifice may be accomplished, for example, through adjustment of the passage length and passage cross sectional area of the orifice passages while giving consideration to characteristic values based on the rigidity of the walls of the pressure-receiving chamber 86 and the equilibrium chamber 88, i.e. on the levels of elastic deformation by the main rubber elastic body 16 and by the diaphragm 74 corresponding to pressure change levels necessary to produce a certain change in unit volume of the chambers 86, 88. Typically, the frequency at which the phase of pressure fluctuations transmitted through the orifice passage changes and assumes the resonance state can be understood as the tuning frequency of the orifice passage.

A movable plate 108 is positioned housed within the circular zone 72 of the partition member 32. This movable plate 108 has a generally circular disk shape that is slightly smaller than the circular zone 72, and is made of a rubber elastic body. A gap is formed all the way around the circumference between the peripheral wall of the circular zone 72 (i.e. the peripheral wall second dividing wall plate 38) and the outside peripheral edge of the movable plate 108. The thickness dimension of the movable plate 108 is smaller in comparison with the axial dimension of the circular zone 72. The pressure of the first pressure-receiving chamber 102 is exerted on a first face of the movable plate 108 (at top in FIG. 1) via the through-holes 58 in the first dividing wall plate 36, while the pressure of the second pressure-receiving chamber 104 is exerted on the other face of the movable plate 108 (at bottom in FIG. 1) via the through-holes 68 in the second dividing wall plate 38. The movable plate 108 is thereby constituted so as to be displaceable in the axial direction within the circular zone **72** on the basis of a relative pressure differential between the first pressure-receiving chamber **102** and the second pressure-receiving chamber **104**.

Guide shaft portions **110**, **110** are disposed in the center section of the movable plate **108** so as to project outward to either side in the axial direction. With the movable plate **108** positioned housed within the circular zone **72**, each guide shaft portion **110** is displaceably inserted into an insertion hole provided in the center section of the first dividing wall plate **36** which defines the upper wall of the circular zone **72** and of the second dividing wall plate **38** which defines its lower wall, thereby positioning the movable plate **108** in the axis-perpendicular direction with respect to the circular zone **72**, and approximately aligning the center axis of the movable plate **108** with the center axis of the engine mount **10** (the mount axis). Since the movable plate **108** has a corrugated shape on either face, due to the smaller striking area of the movable plate **108** against the first dividing wall plate **36** and the second dividing wall plate **38**, noise is reduced, while at the same time ensuring large effective surface area of the movable plate **108** so that pressure of the first and second pressure-receiving chambers **102**, **104** is efficiently exerted on the movable plate **108**.

In this embodiment in particular, the resonance frequency of the movable plate **108** is tuned to a medium frequency range, such as idling vibration or medium speed rumble, that lies within the same range as the tuning frequency range of the second orifice passage **106**, and is set to a lower frequency range compared to the high range of oscillation frequency of the oscillating plate **92** and the resonance frequency of the filter orifice.

A connector rod **112** is vulcanization bonded to the center section of the diaphragm **74**. The connector rod **112** is a rigid rod shaped member that extends in the axial direction, and is provided at a first axial end (at top in FIG. **1**) with a screw hole **114** that opens onto the first end face; its other side in the axial direction is elongated in the axial direction and is provided at its distal end section with a male thread portion **116**. A rimming portion **118** which flares diametrically outward is integrally formed in the axially medial section of the connector rod **112**, and the center section of the diaphragm **74** is vulcanization bonded onto substantially the entire surface of the rimming portion **118**. The connector rod **112** body is thereby vulcanization bonded to the diaphragm **74** so as to penetrate through the center section of the diaphragm **74**.

An electromagnetic actuator **120** that actuates oscillation of the oscillating plate **92** is positioned below the second mounting member **14**. The electromagnetic actuator **120** in this embodiment employs a known design, and since it would be possible to employ a design like that disclosed for example in Japanese Unexamined Patent Publication No. JP-A-2003-339145, the actuator need not be discussed in detail herein except to note that a yoke member **124** which constitutes the stator is positioned spaced apart to the outside peripheral side of a movable member **122** which constitutes the slider. Coils **126**, **127** and permanent magnets **128** are attached to the yoke member **124**, and through the action of electromagnetic force generated between the movable member **122** and the yoke member **124** when electrical current flows to the coils **126**, **127**, the movable member **122** is actuated in the axial direction relative to the stator (the yoke member **124**).

Specifically, the yoke member **124** is formed of a laminated steel sheet made of ferromagnetic material, and while not depicted explicitly in the drawings, has a design in which a pair of magnetic pole portions **130**, **130** project in opposition along an axis-perpendicular direction on the inside peripheral face from a ring shaped outer peripheral magnetic path. The coils **126**, **127** are installed on the pair of magnetic pole portions **130**, **130** by being wound about the perimeter at their respective projecting distal end sections. Each of the coils **126**, **127** is sheathed by an electrical insulating layer **132**. Further, four permanent magnets **128** that are superposed along the lamination direction of the laminated steel sheet are affixed to the inside peripheral face of the pair of magnetic pole portions **130**, **130**. The inside peripheral face of each of the permanent magnets **128** is magnetized to one of S and N polarity, while the outside peripheral face of each of the permanent magnets **128** is magnetized to the other of S and N polarity. The four permanent magnets **128** are arranged with their magnetic poles differing from one another in the superposition direction. In this embodiment, four permanent magnets **128** are disposed in each coil **126**, **127**, accommodated within the approximate center in the axial direction.

The housing **136** of the electromagnetic actuator **120** is positioned to the outside peripheral side of the yoke member **124**. The design of the housing **136** incorporates a large-diameter tubular portion **138** that extends in the axial direction, and an annular plate portion **140** of generally annular plate shape that is fastened to the upper end section of the tubular portion **138** and spreads out in the circumferential direction. The yoke member **124**, which is housed within the tubular portion **138** while sandwiched in the axial direction by a pair of outer tubular washers (spacers) **141**, **141**, is fixedly supported suspended from the annular plate portion **140** by passing elongated fastening bolts **139** through it in the axial direction and then securing nuts **135** onto the distal ends thereof.

The housing **136** is also provided with a lead wire **142**. A first end of the lead wire **142** connects to the coils **126**, **127** inside the housing **136**, while the other end of the lead wire **142** extends out from the outside peripheral face of the housing **136** and hooks up to a power supply **144**. This enables the coils **126**, **127** to be supplied with electrical current from the power supply **144** through the lead wire **142**. As the power supply **144**, it would be possible to employ the installed power supply for the car's electrical system, for example.

Meanwhile, the movable member **122** is disposed to the inside of the yoke member **124**. The design of the movable member **122** incorporates an actuating rod **154** of elongated tube shape, a plurality of magnetic plates **155**, and a plurality of inner tubular washers (spacers) **156** of round tubular shape larger in diameter than the actuating rod **154**. A collar **158** that flares diametrically outward is integrally formed in the upper part of the actuating rod **154**.

The magnetic plates **155** are composed of ferromagnetic material having plate shape, with an insertion hole formed in the center. The inside diameter dimension of this insertion hole is slightly larger than the actuating rod **154**. The length of magnetic plates **155** at their two end edges (length in the left-right direction in FIG. **1**) is shorter by a prescribed amount than the distance between the opposing faces of the pair of permanent magnets **128**, **128** that have been positioned in opposition in the axis-perpendicular direction. The outside diameter dimension of the inner tubular washers (spacers) **156** is smaller than the distance between the opposing faces of the coils **126**, **127** in the axis-perpendicular direction.

With a pair of assemblies, each composed of three magnetic plates **155** stacked in the axial direction, positioned in opposition in the axial direction to either side of the center inner tubular washer **156***b*, and with inner tubular washers **156***a*, **156***c* juxtaposed from outside in the axial direction against the respective stacked magnetic plate **155** assemblies, the magnetic plates **155** and the inner tubular washers **156***a, b,* *c* are slipped about the outside of the actuating rod **154**. The magnetic plates **155** are arranged thereby so as to project outward in the axis-perpendicular direction from the actuating rod **154**, with the axis-perpendicular projecting distal ends (outside peripheral end edges) of the magnetic plates **155** positioned in the axially medial section of the respective coils **126**, **127**, and positioned in opposition to the permanent magnets **128** in the axis-perpendicular direction. The axial distance separating the pair of assemblies of three magnetic plates **155** is smaller than the inside diameter dimension of the coils **126**, **127**.

The end of the connector rod **112** on the opposite side of the rimming portion **118** from the screw hole **114** is slipped into the actuating rod **154**, and a ring shaped spacer **159** is installed fitting about the outside of the male thread portion **116** located at the distal end section of the connector rod **112** which is positioned projecting axially outward from the actuating rod **154**, and a fastening nut **160** is then threaded and fastened thereon. Due to the fastening force of the fastening nut **160** that has been threaded onto the connector rod **112**, the magnetic plates **155** and the inner tubular washers **156** is clamped in the axial direction between the fastening nut **160** and the collar **158** of the actuating rod **154**, and fastened to the actuating rod **154**.

Furthermore, a plurality of supporting plate springs **146** are disposed between the movable member **122** and the yoke member **124**. As depicted in FIGS. **7** and **8**, the supporting plate springs **146** have thin annular disk shape made of spring steel or the like, with a center hole **147** of circular shape formed in the center section. As lightening sections, a plurality of slits **148** are formed in the diametrically medial section of the supporting plate spring **146**, and it will be possible to adjust the substantial effective spring length of the supporting plate spring **146** and to tune its spring characteristics through appropriate design modification of the shape, size, number and/or locations of these slits **148**. The outside peripheral section of the supporting plate spring **146** is perforated by a plurality of bolt insertion holes **150**. In this embodiment in particular, the plurality of slits **148** and the plurality of bolt insertion holes **150** are respectively given identical form and are respectively formed at equidistant intervals in the circumferential direction, thereby eliminating the need to align the supporting plate springs **146** in the circumferential direction.

At least one of these supporting plate springs **146** is positioned to one axial side (at top in FIG. **1**) of the coil **126**, **127**. With the actuating rod **154** passed through the center hole **147** of the supporting plate spring **146** and with the inside peripheral section of the supporting plate spring **146** secured clamped between the collar **158** of the actuating rod **154** and the inner tubular washer **156**, is supported thereby on the movable member **122**. Additionally, at least one more of the supporting plate springs **146** is positioned to the other axial side (at bottom in FIG. **1**) of the coil **126**, **127**. With the actuating rod **154** passed through the center hole **147** of the supporting plate spring **146** and with the inside peripheral section of the supporting plate spring **146** secured clamped between the inner tubular washer **156** and the spacer **159**, is supported thereby on the movable member **122**.

Fastening bolts **139** for securing the yoke member **124** to the housing **136** are passed through each of the bolt insertion holes **150** that have been formed in the outside peripheral section of each of the supporting plate springs **146**. The outside peripheral section of the supporting plate springs **146** are clasped, via a ring shaped washer **161**, between one of the outer tubular washers **141** and the annular plate portion **140**, and via another ring shaped washer **161**, between the other outer tubular washer **141** and the nuts **135**. The outside peripheral sections of the supporting plate springs **146** are secured clamped in the axial direction, and supported on the yoke member **124** through screw fastening of the fastening bolts **139** and the nuts **135**.

With this arrangement, the movable member **122** is elastically supported at both axial sides by the supporting plate springs **146** which extend in the axis-perpendicular direction, and the movable member **122** is positioned concentrically with the housing **136** incorporating the yoke member **124**, and is supported displaceably in the axial direction to the inside of the yoke member **124**. Additionally, the pair of assemblies composed of three magnetic plates **155** stacked adjacently in the axial direction is positioned in opposition to the permanent magnets **128** of the yoke member **124** across a small gap in the axis-perpendicular direction.

In this embodiment in particular, the supporting plate springs **146** which support the movable member **122** at both of its axial sides are deployed in sets of two situated to either side in the axial direction, and are juxtaposed fluid-tightly against the movable member **122** in the axial direction. As the slits **148** which have been formed in each of the supporting plate springs **146** are situated at projected locations in the axial direction, the slits **148** will overlap so as to communicate with one another.

A saucer shaped cover member **163** is attached to the opening section of the tubular portion **138** of the housing **136** so as to cover the opening section of the tubular portion **138**. The movable member **122** and the yoke member **124** situated inside the electromagnetic actuator **120** is thereby protected from the outside by the tubular portion **138** and the cover member **163**.

The lower end face of the outside peripheral section of the annular plate portion **140** of the housing **136** in the electromagnetic actuator **120** is juxtaposed against the upper end face of the inside peripheral section of the lower end plate fitting **84***b* of the bracket member **80**, and is bolted thereto. The electromagnetic actuator **120** is thereby securely supported on the second mounting member **14** via the bracket member **80**.

As noted above, the end of the connector rod **112** on the opposite side of the rimming portion **118** thereof from the screw hole **114** is slipped into the actuating rod **154**, and the distal end section of the connector rod **112** is then screwed into the fastening nut **160** so that the connector rod **112** and the actuating rod **154** are connected to one another approximately along the center axis of the mount **10**.

Furthermore, the upper end face of the connector rod **112** is juxtaposed against the lower end face of the center section of the oscillating plate **92**, and a fastening bolt **162** is passed through the insertion hole **96** from above the boss shaped projection **94** of the oscillating plate **92** and screwed into the screw hole **114** of the connector rod **112**. The movable member **122** of the electromagnetic actuator **120** is thereby fastened to the oscillating plate **92** via the connector rod **112**. From the above description it will be appreciated that the electromagnetic actuator **120** is situated to the opposite side of the oscillating plate **92** from the pressure-receiving chamber **86**.

The boss shaped projection **94** which projects from the upper end section of the oscillating plate **92** is linked to the partition member **32** via a plate spring **164**. As depicted in FIG. **9**, this plate spring **164** has a thin annular disk shape made of spring steel or the like, with a center hole **165** of circular shape formed in the center section. The inside diameter dimension of the plate spring **164** is smaller than the outside diameter dimension of the boss shaped projection **94** of the oscillating plate **92**, while the outside diameter dimension of the plate spring **164** is slightly smaller in comparison with the outside diameter dimension of the step portion **44** of the center hole **42** of the partition member **32**. As lightening sections, a plurality of slits **166** are formed in the diametrically medial section of the plate spring **164** and penetrate through the plate in its thickness direction; and a plurality of bolt insertion holes **168** are formed at locations corresponding to the screw holes **50** which have been formed in the step portion **44** of the center hole **42** of the partition member **32** in the outside peripheral section. In this embodiment, three slits **166** and three bolt insertion holes **168** are formed at equidistant intervals in the circumferential direction.

The center hole **165** of the plate spring **164** and the insertion hole **96** of the oscillating plate **92** are superposed at mutually projected locations in the axial direction, and the fastening bolt **162** is then passed through the center hole **165** and the insertion hole **96**, and threadably fastened with the inside peripheral section of the plate spring **164** positioned clamped between the head of the fastening bolt **162** and the boss shaped projection **94**. The outside peripheral section of the plate spring **164** rests on the step portion **44** of the center hole **42**, the bolt insertion holes **168** of the plate spring **164** are aligned with the screw holes **50** of the step portion **44**, and the outside peripheral section of the plate spring **164** is then bolted to the partition member body **34**. With this arrangement, the plate spring **164** is disposed so as to extend in the axis-perpendicular direction on the opposite side of the oscillating plate **92** from the electromagnetic actuator **120**, and the oscillating plate **92** is elastically linked to and supported in the axial direction by the partition member **32**, by means of the plate spring **164**. That is, in association with actuation of the movable member **122** in the axial direction, the plate spring **164** will experience elastic deformation in the axial direction as well, and by virtue of being positioned in the axis-perpendicular direction by the plate spring **164**, the oscillating plate **92** is maintained in a state with the oscillating plate **92** and the cylinder shaped hole **46** positioned concentrically. In other words, the gap **100** is maintained all the way around the circumference between the outside peripheral edge of the oscillating plate **92** and the peripheral wall of the cylinder shaped hole **46**.

In the same way as the zone between the plate spring **164** and the second dividing wall plate **38**, the zone between the plate spring **164** and the oscillating plate **92** is filled with fluid through the slits **166** of the plate spring **164**, so that the zone constitutes part of the second pressure-receiving chamber **104**.

In the automotive engine mount **10** of the construction described above, through flow of electrical current to the coils **126**, **127** in one direction about the diametrical axis of the magnetic pole portion **130** in the electromagnetic actuator **120**, an N pole is produced to the diametrical inward side of the yoke member **124**, while an S pole is produced to the diametrical outward side. When the current flow to the coils **126**, **127** is reversed, the N poles and S poles of the plurality of permanent magnets **128** attached to the yoke member **124** will weaken and strengthen in alternating fashion. As a result, force in one direction and force in the other direction will act in alternating fashion upon the movable member **122**, causing the movable member **122** to undergo reciprocating motion to either side in the axial direction from its equilibrium position in the absence of current flow (the position depicted in FIG. **1**). From the above description it will be appreciated that the design of the output member that is passed through the diaphragm **74** and linked to the oscillating plate **92** incorporates the movable member **122** and the connector rod **112**.

Through feedback control, such as adaptive control using the engine ignition signal of the power unit as a reference signal and the vibration sensor signal of a component to be damped (such as the vehicle body) as an error signal for example, electrical current to the coils **126**, **127** are controlled thereby in order to actuate oscillation of the movable member **122** in the axial direction. As a result, at times of input of low-frequency vibration such as engine shake, or at times of input of medium-frequency vibration such as engine idling or low speed rumble for example it will be possible, through actuation control of the oscillating plate **92** so as to effectively give rise to pressure fluctuations between the pressure-receiving chamber **86** and the equilibrium chamber **88**, to effectively achieve vibration damping action based on resonance action of fluid through the first orifice passage **90**, or vibration damping action based on resonance action of fluid through the second orifice passage **106**.

In this embodiment in particular, the head of the fastening bolt **162** which has been fastened to the boss shaped projection **94** of the oscillating plate **92**, and the guide shaft portions **110** of the movable plate **108** are positioned in opposition a prescribed distance apart in the axial direction. It is accordingly possible, for example, to actuate the oscillating plate **92** upward so that the guide shaft portions **110** are pushed by the fastening bolt **162**, thereby holding the movable plate **108** in a state of abutment against the first dividing wall plate **36**. The through-holes **58** of the first dividing wall plate **36** is covered by the movable plate **108** and displacement of the movable plate **108** is constrained, thereby making it possible to substantially prevent flow action of fluid from arising through the second orifice passage **106**, that is, to block off the second orifice passage **106**. For this reason, as long as the second orifice passage **106** is maintained in a blocked off state at times of input of vibration lying in the tuning frequency range of the first orifice passage **90**, pressure leakage from the pressure-receiving chamber **86** through the second orifice passage **106** will be prevented with a higher level of reliability so that the vibration damping effect afforded by the first orifice passage **90** may be more effectively achieved.

It is also possible, for example, to actuate downward displacement of the oscillating plate **92** so that the rim shaped projection **98** of the oscillating plate **92** is held in a state of abutment against the inner flanged portion **48** of the partition member **32**, and thus to prevent flow action of fluid from arising between the second pressure-receiving chamber **104** and the equilibrium chamber **88**, through gap **100** between the oscillating plate **92** and the cylinder shaped hole **46**, in a yet more highly reliable manner. Thus, by maintaining the outside peripheral section of the oscillating plate **92** (the rim shaped projection **98**) against the inner flanged portion **48** at times of input of vibration lying in the tuning frequency range of the second orifice passage **106**, pressure leakage from the second pressure-receiving chamber **104** through the gap **100** will be prevented in a yet more highly reliable manner, and the vibration damping effect afforded by the second orifice passage **106** may be more effectively achieved.

In this embodiment, the face of the inner flanged portion **48** positioned facing the oscillating plate **92** is sheathed by a rubber cushioning layer **170** that extends with generally unchanging thickness dimension about the entire perimeter. Since the oscillating plate **92** will strike the inner flanged portion **48** via the intervening rubber cushioning layer **170**, the problem of noise associated with striking can be ameliorated through the cushioning action of the rubber cushioning layer **170**.

Additionally, at times of input of medium- to high-speed rumble in a frequency range higher than the tuning frequency range of the first orifice passage **90** and the second orifice passage **106**, actuating force corresponding to the vibration in question is directed onto the oscillating plate **92**. The internal pressure of the pressure-receiving chamber **86** which incorporates the first and second pressure-receiving chambers **102**, **104** is thereby controlled on the basis of actuated oscillation of the oscillating plate **92** to effectively provide positive and active vibration damping action against the high frequency vibration.

In this embodiment in particular, the resonance frequency of fluid flowing through the through-holes **58**, **68** in the first and second dividing wall plates **36**, **38** and through the circular zone **72** is tuned to a high frequency range such as medium- to high-speed rumble in order to achieve active vibration damping action by the oscillating plate **92**; and in combination therewith, pressure fluctuations arising in the first pressure-receiving chamber **102** and the second pressure-receiving chamber **104** on the basis of actuated oscillation of the oscillating plate **92** is transmitted efficiently utilizing the resonance action of the fluid caused to flow through the through-holes **58**, **68** and the circular zone **72**. The vibration transmission characteristics of the first mounting member **12** and the second mounting member **14** linked by the main rubber elastic body **16** may then be adjusted through positive and active control of the pressure fluctuations arising in the first pressure-receiving chamber **102** and the second pressure-receiving chamber **104**, to advantageously produce the desired vibration damping action.

The oscillating plate **92** is supported positioned in the axis-perpendicular direction at one axial side thereof by the movable member **122** of the electromagnetic actuator **120**, and is supported positioned in the axis-perpendicular direction at the other axial side thereof by the plate spring **164**. The oscillating plate **92** is thereby supported positioned in the axis-perpendicular direction to either side in the axial direction with respect to the partition member **32**, thereby affording excellent suppression of displacement of the oscillating plate **92** in the axis-perpendicular direction, as well as of displacement in a twisting direction.

As a result, actuation efficiency of the oscillating plate **92** in the axial direction is improved, and the desired vibration damping action will be effectively achieved. Additionally, the likelihood of the oscillating plate **92** contacting the peripheral wall of the cylinder shaped hole **46** will be minimized, thereby avoiding the anxiety of damage etc. resulting from such contact.

Additionally, because the oscillating plate **92** is supported at either side of its center axis by the partition member **32**, problems caused by interference of the oscillating plate **92** with the cylinder shaped hole **46** can be eliminated, while keeping the gap **100** between the outside peripheral face of the oscillating plate **92** and the inside peripheral face of the cylinder shaped hole **46** sufficiently small and providing the opposed sections of the oscillating plate **92** and the cylinder shaped hole **46** in the axial direction with considerable length in the axial direction. This has the effect of increasing the piston surface area of the opposed sections of the oscillating plate **92** and the cylinder shaped hole **46**, while inhibiting pressure leakage from the pressure-receiving chamber **86** through the gap **100** so as to stabilize and enhance the efficiency of pressure control of the pressure-receiving chamber **86**.

Furthermore, in the embodiment, employing the plate spring **164** affords the advantage of allowing sufficient displacement of the oscillating plate **92** in the axial direction, while effectively positioning it in the axis-perpendicular direction. Moreover, as the axial dimension of the plate spring **164** is typically small, problems in terms of ensuring adequate space or larger size in association with installation of the plate spring **164** in the mount **10** are eliminated.

While the present invention has been described in detail in its presently preferred embodiment, it is to be understood that the invention is by no means limited to the details of the illustrated embodiment and may be embodied with various changes, modifications and improvements which may occur to those skilled in the art, without departing from the spirit and scope of the invention.

For example, the shape, size, construction, number, placement and other aspects of the oscillating plate **92**, the plate spring **164**, the first orifice passage **90**, the second orifice passage **106**, the filter orifice, the movable plate **108** etc. are not limited to those taught herein by way of example. In particular, the second orifice passage **106**, the filter orifice, the movable plate **108** may be provided on an as-needed basis and are not essential elements.

Also, whereas in the embodiment hereinabove the oscillating plate **92** is furnished with a single plate spring **164** only, the plate spring **164** could instead have a stacked construction in which a plurality of plate springs **164** are stacked in the actuation direction of the oscillating plate **92** as depicted in FIG. **10**, for example. In this case, the plurality of plate springs **164** may be juxtaposed in intimate contact, or juxtaposed at projected locations while respectively spaced apart in the actuation direction of the oscillating plate **92**. In the description with reference to FIG. **10** and other embodiments different from the embodiment hereinabove, elements substantially identical in construction to the embodiment above are designated by like reference numerals and are not discussed in detail.

Furthermore, where a plurality of plate springs **164** are juxtaposed as depicted in FIG. **10**, the slits **166** which have been formed as lightening sections in the plate springs **164** may be juxtaposed so as to communicate with one another.

Additionally, the electromagnetic actuator employed may be one with a construction in which, as shown by way of example herein, the permanent magnets **128** are disposed on the slider side while the coils **126**, **127** and the yoke member **124** are disposed on the stator side so that the N poles and S poles on the slider side increase and decrease in alternating fashion by means of the magnetic field created when current is passed through the coils **126**, **127**, causing the slider to undergo reciprocating motion; or an electromagnetic actuator of conventional construction such as that disclosed in Japanese Unexamined Patent Publication No. 2000-213586 or U.S. Pat. No. 6,422,546, in which, using a single permanent magnet, the slider is actuated to one side in the axial direction through the action of a magnetic field created when current is passed through a coil, while the slider is actuated to the other side in the axial direction using the urging force of a coil spring or the like.

Moreover, the partition member body **34** need not be a single component as shown herein by way of example. Instead, several components may be assembled together, for example, which will have the effect of improving freedom in tuning of the shape, length, cross sectional area etc. of the first and second orifice passages.

Additionally, whereas in the embodiment hereinabove the second pressure-receiving chamber **104** and the equilibrium chamber **88** communicate with one another through the second orifice passage **106**, it would be possible for the first pressure-receiving chamber **102** and the equilibrium chamber **88** to communicate with one another, for example.

Also, while in the embodiment hereinabove the movable plate **108** is disposed within the circular zone **72** that constitutes the filter orifice, the movable plate **108** could be disposed at a separate location independent from the filter orifice.

Additionally, while the embodiment herein describes the invention reduced to practice in an automotive engine mount, the invention could be implemented analogously in a body mount or diff mount, or in vibration damping devices for various non-automotive vibrating bodies as well.

What is claimed is:

1. A fluid filled type vibration damping device comprising:

a rubber elastic body elastically connecting a first mounting member and a second mounting member;

a partition member supported on the second mounting member;

a pressure-receiving chamber whose wall is partly defined by the rubber elastic body; an equilibrium chamber whose wall is partly defined by a flexible film; the pressure-receiving chamber and the equilibrium chamber being formed to either side of the partition member and filled with a non-compressible fluid;

a first orifice passage connecting the pressure-receiving chamber and the equilibrium chamber; an oscillating plate defining another part of the wall of the pressure-receiving chamber; and

an electromagnetic actuator for actuating oscillation of the oscillating plate,

wherein the oscillating plate is constituted by including a cylinder shaped hole having a round tubular inside peripheral face formed in the partition member, and a piston shaped plate accommodated within the cylinder shaped hole with a gap provided between an outside peripheral face of the piston shaped plate and the inside peripheral face of the cylinder shaped hole so that the piston shaped plate is axially displaceable within the cylinder shaped hole,

an output member of the electromagnetic actuator is passed through the flexible film and linked to the piston shaped plate,

a plate spring extending in an axis-perpendicular direction is disposed to an opposite side from the electromagnetic actuator with the piston shaped plate therebetween, with the oscillating plate being elastically linked to and supported in an axial direction with respect to the partition member by the plate spring, and

the oscillation plate is supported at both sides of a center axis thereof such that the oscillating plate at a first side thereof in an axial direction is positioned and supported in an axis-perpendicular direction by an output member of the electromagnetic actuator, and another side thereof in the axial direction is positioned and supported in the axis-perpendicular direction by the plate spring.

2. The fluid filled type vibration damping device according to claim **1**, wherein the electromagnetic actuator includes a design whereby the output member is elastically supported with respect to a housing of the electromagnetic actuator by a supporting plate spring that extends in the axis-perpendicular direction.

3. The fluid filled type vibration damping device according to claim **1**, wherein the pressure-receiving chamber is partitioned by a dividing wall member that is disposed in a medial section of the pressure-receiving chamber in order to form to either side of the dividing wall member a first pressure-receiving chamber whose wall is partly defined by the rubber elastic body and a second pressure-receiving chamber whose wall is partly defined by the oscillating plate, and a filter orifice is provided for connecting the first pressure-receiving chamber and the second pressure-receiving chamber.

4. The fluid filled type vibration damping device according to claim **3**, wherein a second orifice passage is provided connecting the second pressure-receiving chamber and the equilibrium chamber, with the second orifice passage being tuned to a higher frequency range than the first orifice passage, the filter orifice is formed in the dividing wall member, and a movable plate is displaceably disposed in the filter orifice such that pressure of the first pressure-receiving chamber is exerted on a first face of the movable plate while pressure of the second pressure-receiving chamber is exerted on another face of the movable plate.

5. The fluid filled type vibration damping device according to claim **1**, wherein the cylinder shaped hole is formed in a center section of the partition member so as to extend in a direction of opposition of the pressure-receiving chamber and the equilibrium chamber, with the wall of the equilibrium chamber being defined in part by an outside peripheral section of the partition member about the cylinder shaped hole, and an outside peripheral face of the partition member has a tapering contour decreasing in diameter from a first axial end of a pressure-receiving chamber side thereof towards another axial end on an equilibrium chamber side.

6. The fluid filled type vibration damping device according to claim **1**, wherein a plurality of plate springs are disposed in a stacked structure by being juxtaposed in a direction of actuation of the oscillating plate.

7. The fluid filled type vibration damping device according to claim **6**, wherein a lightening section is formed in each plate spring, and the plurality of plate springs are juxtaposed with the lightening sections communicating with one another.

8. The fluid filled type vibration damping device according to claim **4**, wherein the oscillating plate is movable to push and hold the movable plate in a state so that the second orifice passage is blocked off.

9. The fluid filled type vibration damping device according to claim **4**, wherein the oscillating plate is movable to be held in a state of abutment against the partition member so as to prevent flow action of fluid from arising through the gap between the outside peripheral face of the piston shaped plate and the inside peripheral face of the cylinder shaped hole.

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